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Cover picture: *this print of hay harvesting is taken from an eighteenth-century French book,* La Nouvelle Maison Rustique (*Tome I, 7th edition, 1755*) *by Louis Liger, who was born at Auxerre in 1658. The author has been described as an agricultural expert; his book was based on an earlier work,* Praedium Rusticum, *published by Charles Estienne in 1554. A copy of the 7th edition of Liger's book is in the Bibliotheque Nationale, Paris; the British Museum, London, has a copy of the 6th edition of 1749.*

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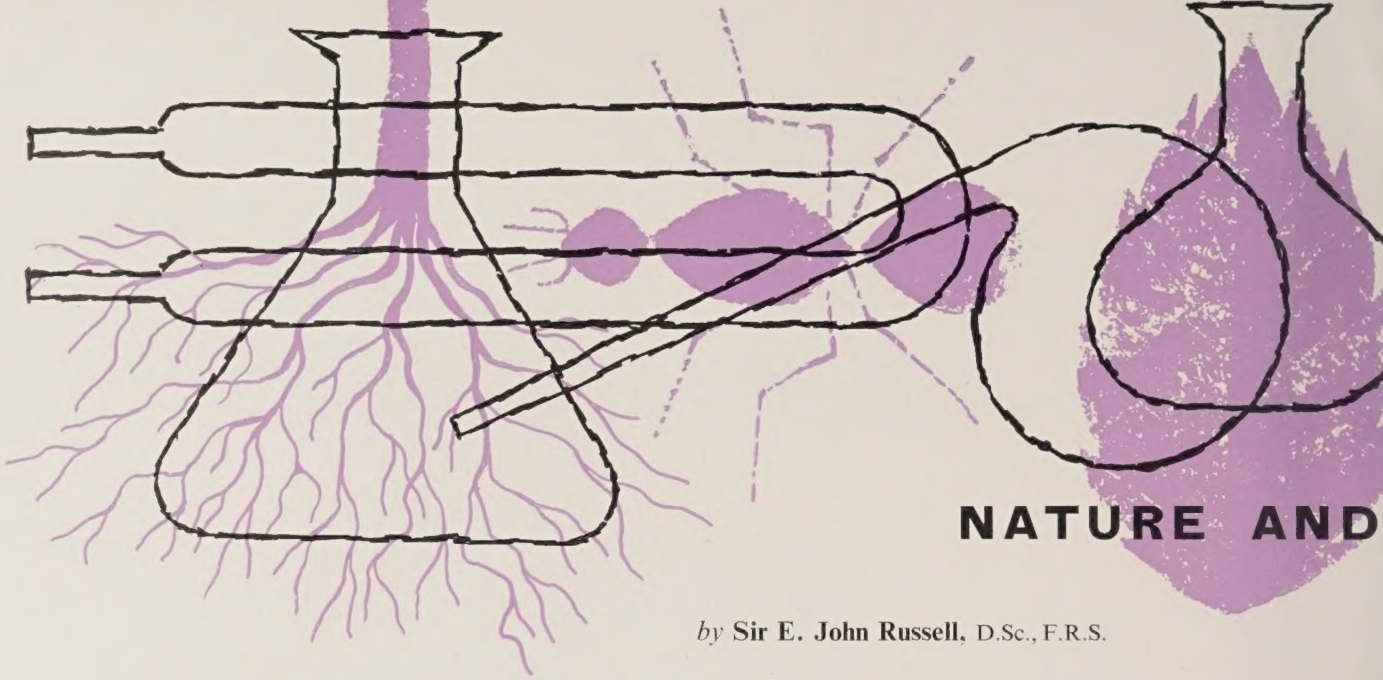


NATURE AND

by **Sir E. John Russell,** D.Sc., F.R.S.

Recent years have seen a tremendous increase in the quantity of agricultural chemicals—both fertilisers and pesticides—applied to the soil and to living crops. That these chemicals are of paramount importance in increasing crop yields—and therefore world food production—is not in doubt. But as the use of pesticides, especially, grows, doubts are from time to time expressed in various quarters about what their long-term effect may be on the soil, wild life, domestic animals and even on man himself.

It is only during the past few years that pesticides have come to be used on a wide scale, and for this very reason it is impossible for anybody to state categorically what effects their use will have over a long period. In the following article, however, Sir John Russell looks at the evidence so far available and summarises what has been learnt (principally from the standpoint of British farming) about this subject.

Sir John leaves us in no doubt that chemicals must *be used in agriculture and suggests that if they are carefully chosen and properly applied their use need give little cause for anxiety.*

Chemists were the first outsiders to break into the domain of the farmer. Robert Boyle had hinted at it in the 1660s, Humphrey Davy went further in the 1810s, but the first successful effort came about 1837 when John Bennett Lawes of Rothamsted began experiments with manures which led him in 1843 to set up the first fertiliser factory, and with Joseph Henry Gilbert to start the famous field experiments that showed the remarkable effects of the new fertilisers on the growth of plants. The fertilisers had a mixed reception from farmers: many took them up, but others did not, maintaining that they were stimulants only and quite unnatural: in the end they would poison the soil and the crop, perhaps also the consumer.

Long continued field experiments showed that with proper safeguards these fears were groundless: the great body of farmers now accept fertilisers as indispensable aids to production. Problems are always liable to arise, however, necessitating constant attention from scientists and a higher standard of education for the farmer. This is being achieved: more than a million tons a year of the plant nutrients N, P_2O_5 and K_2O are now used by farmers of the United Kingdom and the consumption still increases; yields also are still going up although much of our land has been cultivated for more than a thousand years.

Chemistry achieved no comparable agricultural triumphs till after the last war, when the revolutionary developments in technological organic chemistry enabled manufacturers to produce by the thousand tons a prodigious number of substances previously obtainable only in small quantities in the laboratory. The most widely used of these new chemicals are the weedkillers. About 5,000,000 acres annually in Great Britain and some 50,000,000 acres in North America are sprayed with no harmful effects provided the proper precautions are taken.

Some of the synthetic hormones are used by horticulturalists for bringing about development of roots on cuttings, the setting of fruit, retarding or hastening of ripening, prevention of early fall of fruit, sprouting of stored potatoes and other changes. Synthetic animal hormones are used by farmers for hastening the fattening of animals and producing leaner and more juicy meat, for ensuring more twins, and other purposes (4).

Exception has been taken to some of these operations in that they are wholly unnatural: outraged Nature, it is feared, will revolt, with dire effects on the human race. With proper care, however, no untoward consequences have as yet resulted.

Seed Treatment

Bunt was formerly a dreaded disease of wheat: it gave the grain a dark colour and an unpleasant taste making it unusable for bread, although it could be used for making

gingerbread as the treacle disguised both colour and taste. A favourite remedy was to soak the seed in brine or dress it with copper sulphate: germination was, however, liable to be impaired and seedling growth retarded. In the 1920s chemists produced the organo-mercury compounds—a great advance on the old methods. Fears that regular use of these compounds might lead to a harmful accumulation of mercury in the soil proved groundless, the mercury apparently being converted into an innocuous compound (1).

An insecticide can be added to afford wider protection: LANE (6) suggests that a systemic insecticide should be used to extend the protection to the young plants. Modern agents have raised no new problems and are so successful that farmers are generally advised to treat all cereal seed.

Copper and Sulphur

Chemical treatment of fungus diseases of plants began about 1882 in France with the accidental discovery that Bordeaux mixture saved the vines from the destructive mildew. It was widely used with apparently no harmful effects for some 40 years, when crops grown in the vineyards after grubbing the vines were found to be poisoned: this was traced to copper from the spray which got on to the soil and remained in the surface layer. Further trouble was caused by the sulphur used against powdery mildew in the drier regions: when it fell on to the soil it became oxidised and formed sulphuric acid. Both troubles are apparently increasing in France; amounts of copper up to 200 ppm have recently been recorded in the top 25cm. and the acidity of the soil, already high (between pH 4.0 and 5.0), has been raised above the danger level for some of the crops, especially leguminous crops.

British hop gardens have for many years been sprayed with Bordeaux mixture or other copper compounds, yet Mr. A. H. BURGESS, one of our leading hop experts, tells me he knows of no instance of damage that could be attributed to accumulation of copper in the soil. Hop gardens differ from vineyards, however, in that they are heavily manured and the soils are nearly neutral.

Trouble has been known to arise when fungicides have been used in the soil against pathogenic fungi: resistant strains have developed and multiplied freely when their competitors were killed. Potato scab was increased in some Michigan experiments, as was crown gall damage by *Aspergillus niger* to groundnut seedlings in Tanganyika (2, 3, 7). Apart from these few cases no harm seems to arise from properly used fungicides.

Effects of Insecticides

Insects have shown more markedly than fungi such effects as the emergence of resistant strains, and also pest resurgence resulting from disequilibrium that has arisen between pests and their natural enemies.

Insecticides are more extensively used than fungicides, and chemists have done much more in extending their range and their number; some are very potent and have raised serious problems. The killing of predators enabled certain insects previously of small account to multiply and become pests, among them the red spider mite in British orchards, woolly aphis in California, and the young stages of the cabbage root fly also in Britain (at Wellesbourne). This aspect of the subject has been fully discussed by Professor V. B. WIGGLESWORTH (12 and 13). He recognises the necessity for insecticides, but emphasises the need for studying their effects on the whole insect population associated with the pest, instead of confining the investigation to the pest alone. The aim should be to establish an equilibrium in which the possibility of damage is reduced to a minimum; this necessitates ecological studies in which the insecticide is one factor, but not the whole determinant.

The East Malling investigators also attach great importance to the predators in the insect population and aim at developing spray programmes that will make the

fullest use of them. Where certain predators are present it is pointed out by A. M. Massee that summer spraying of orchards may do more harm than good. Dr. Tubbs states, however, that only one fruit pest, red spider, appears to be really susceptible to biological control, and the predators are not always sufficiently numerous.

Difficulties arise from the fact that strains of some insects are emerging which are resistant to certain insecticides. DDT was introduced in 1939, at first against lice and mosquitoes affecting human beings: by 1957, 38 species had become resistant, including plague-carrying fleas, typhus-carrying lice, and malaria-transmitting mosquitoes, the World Health Organisation has reported. The black scale and red scale insects of California have developed resistance to hydrocyanic acid as has a cattle tick to arsenic, and the red spider mite to organo-phosphorus insecticides.

Biological control avoids these difficulties, and, as Professor Varley points out (11) where it works it is admirable but this does not often happen: T. H. C. Taylor (10) found fewer than 20 instances of complete control during the period 1905-55. Kenneth Smith (9) made the interesting suggestion that viruses might be produced and liberated, effecting destruction, just as myxomatosis eliminated rabbits for a time: he quotes two successes—control of pine sawfly in Norfolk, and a cabbage butterfly in California. In Canada attempts have been made to breed more potent strains of predators.

More Chemicals Used

Meanwhile more chemicals than ever are being used by farmers and horticulturalists. The urgent need for more food has compelled the adoption of more intensive methods necessitating far more fertiliser and reduction of wastes and losses. Fortunately many destructive weeds, pests and diseases that formerly had to be endured can now be controlled: among others, wireworms, leather jackets, nematodes in the soil, potato blight, capsids, apple blossom weevil, and aphids carrying virus diseases to potatoes and sugar beet.

This has necessitated continually increasing application of herbicides, fungicides, insecticides and other chemicals. Fruit and hop growers who formerly sprayed only about twice in the season now spray six, 10, even in extreme cases, 20 times. Dr. Kearns thinks this can be reduced by better distribution and at Long Ashton research is directed to ensuring greater efficiency and therefore fewer sprayings. But spray the fruit grower must, and he has the further compulsion that the British housewife is a fastidious buyer and blemishes that formerly passed unnoticed may now make the fruit unsaleable.

Unfortunately, none of the sprays is entirely simple in its action, and other effects, some of them harmful, may be produced. As these are discovered, methods of avoidance are sought and in a number of cases found. Properly used there need be no fears about the fertilisers, hormone herbicides (except from spray drifting), present day fungicides, and many insecticides including probably the systemic. But risks are attached to certain materials such as DNOC, arsenites, some chlorinated hydrocarbons and some other insecticides, notably organic phosphorus compounds.

In the United Kingdom a Government inter-departmental committee with scientific advisory sub-committee has these matters under review and advises as to suitable action. The Ministry of Agriculture Poisonous Substances Regulations require the use of protective clothing when spraying some of these materials, thus greatly reducing the hazard to the worker. But injury to bees (5 and 8) birds and other wild animals may result, and spray material adhering to the product, particularly fruit, may injure human beings. Recently much public anxiety has been aroused. Mr. J. B. Godber, Parliamentary Secretary to the Ministry of Agriculture, putting the matter into perspective late last year, stated that the proportion of pesticides dangerous to human beings and mammals was falling: it had been about five per cent. of the total but was now down to about three-and-a-half per cent., and will fall still lower when arsenite spraying of potato haulm is finally discontinued[1].

The losses caused by pests can be estimated only roughly and figures sometimes appearing in the Press are little better than guesses. Experts of the Ministry of Agriculture in Britain have for some years been engaged in making valid estimates of the damage done, and these will furnish really reliable data.

The chemist's task is difficult. He has to find a substance that will quickly kill a selected few out of a varied insect population—there may be 50 or more different species—and it must not be used in such a way as to kill bees or injure humans or domestic animals. Fortunately there is a practically unlimited number of substances to choose from.

But the chemist cannot single-handed solve the problem. Parallel investigations are needed in insect physiology and in the relations of chemical constitution to physiological activity. The knowledge thus gained will enable the chemist to concentrate on materials far more toxic to the insect pest than to predators or others that it is desired to conserve, and will show how they can be used with minimum risk of toxic hazard to man and animals.

REFERENCES

(1) Booer, J. R., *Ann. appl. Biol.*, **31**, 344-59, 1944.
(2) Garrett, S. D., *Biology of Root Infecting Fungi*, Cambridge, 1956.
(3) Garrett, S. D., *Trans. Brit. mycol. Soc.*, **41**, 157-64, 1958.
(4) Hammond, J., *Outlook on Agriculture*, **1**, 230-4, 1957.
(5) Hocking, B., *Bee World*, **31**, 7, 49-53, 1950.
(6) Lane, M. O., *Span*, **2**, 1, 36-9, 1959.
(7) Parry, K. E. and Wood, R. K. S., *Ann. appl. Biol.*, **46**, 446-56, 1958.
(8) Sanger, A. M. H., *Span*, **2**, 2, 59-63, 1959.
(9) Smith, K. M., *Outlook on Agriculture*, **2**, 178-84, 1959.
(10) Taylor, T. H. C., *Ann. appl. Biol.*, **42**, 191, 1955.
(11) Varley, G. C., *J. Roy. Soc. Arts*, **107**, 475-90, 1959.
(12) Wigglesworth, V. B., *Adv. Sci.*, Lond., **7**, 26, 154-61, 1950.
(13) Wigglesworth, V. B., *Agric. Progr.*, **32**, 5-15, 1957.

[1] Since this article was written it has been announced that arsenite haulm destroyers and weed killers will not be available for use in Britain after 1960 [Ed.].

Field Evaluation of selective Herbicides

by **J. D. Fryer,** *Agricultural Research Council Unit of Experimental Agronomy, University of Oxford.*

Since the war, in temperate and tropical countries alike there has been an ever increasing interest in the evaluation of selective herbicides, a process aimed at finding out how chemicals having herbicidal properties can assist the economical production of crops on farms, market gardens, nurseries and forests. Much of the work is carried out by weed control specialists who have many years' experience to help them decide how best to test each new herbicide as it becomes available from commercial or official research organisations. A great deal, however, if it is to be done at all, has to be carried out by agronomists, advisers and others to whom weed control work is but a small part of their job to be fitted in as time and interest allow.

All too often, the results of experimental work carried out with herbicides are inconclusive or misleading, and much time is wasted, because of a lack of awareness of the principles underlying the testing of herbicides, a subject that is as unfamiliar to most students of crop production as no doubt the testing of fertilisers was 50 years ago.

The purpose of this article is to help those who are faced with the task of testing herbicides, but who are not sure how to set about it, to make their effort as fruitful as possible.

Information

Before a step is taken into the field to test a new herbicide, it is commonsense to find out as much as possible about the chemical and its mode of action. Information on the label is a guide but it is seldom comprehensive and, indeed, may have little relevance to local conditions. However, commercial firms supplying samples for trial are generally most cooperative in making available information about their products. In general, the minimum information about a new herbicide to allow the planning of a satisfactory programme of field testing is as follows:

(1) Name and concentration of active chemical;
(2) Method of formulation;
(3) Whether translocated in the plant or a 'contact' herbicide;
(4) Whether active when applied to the leaves or only when applied to the soil;
(5) Evidence of the susceptibility of any crops or weeds on which it has been tested and an indication of the effective dose range;
(6) Some information on persistence in soils;
(7) An indication of its toxicity to man and animals and special precautions with regard to handling.

It is fair to say that at least some information under each of these headings will be available to the manufacturers before the chemical reaches the hands of the field investigator, and only in exceptional instances will it be withheld from anyone seriously interested in field testing.

Having obtained all the available information about a new herbicide, the next step is to consider the situations for which it may possibly prove of value. It is helpful to

remember that there are three periods (Figure 1) in the life-history of a crop, during which applications of herbicides may be useful:

(1) Before the crop is sown or planted, to kill perennial weeds or to prevent annual weeds from becoming a problem (pre-planting treatments);

(2) After the crop has been sown or planted but before it has emerged, mainly to prevent the establishment of annual weeds (pre-emergence treatments);

(3) In the established crop (post-emergence).

During each of these three periods herbicides may be applied either before the weeds have emerged (soil treatment) or afterwards (shoot treatment). For a comprehensive programme of field evaluation, all six possibilities should be considered. In practice, the majority of herbicides can be classified as being most effective when applied either to the soil or to the aerial shoots of weeds, and any one herbicide is likely, therefore, to be of use in not more than three of the above situations. For instance, dalapon can be used for controlling perennial grasses before planting potatoes, after planting and after emergence, in each case being applied to the foliage of the grasses.

Planning

It may be desired to test a new herbicide for just one problem, maybe for the control of one weed species in a single crop or, at the other extreme, for a range of weeds in several crops. It will depend on the number and importance of the weed problems, on the potential merits of the herbicides as judged from existing information and on the labour available for field work. When planning a programme of evaluation work, it is helpful to think of the field evaluation process as being divided chronologically into three phases (1):

(1) *An exploratory phase*, in which experience is gained of the selectivity (Figure 2) of the herbicide and potential applications;

(2) *A phase of consolidation*, when detailed information is obtained on the response of selected crops and weeds, and when attention is given to methods of application and if necessary to formulation, also to soil persistence and hazards.

(3) *A phase of integration and new agronomic techniques*, in which experimental work is carried out to integrate biologically successful treatments that have emerged from phase 1 and phase 2 investigations into existing methods of crop culture; also to evolve new techniques of crop production based on the existence of a novel chemical method of weed control.

If sufficient locally obtained evidence is available to the experimenter when he receives a new herbicide for evaluation, it may be possible to dispense with phase 1 and phase 2 investigations, but generally it is necessary to start at the beginning, in order to gain first-hand experience of the reaction of crop and weeds to the herbicide, before attempting the laborious experiments that are required to assess its influence on methods of crop production. All too frequently, complicated experiments designed, for example, to compare the yield of crop after a herbicide application with that after hand or mechanical weeding, have failed to give any worthwhile results for the simple reason that insufficient information about the herbicide was available to enable the planner to predict satisfactory weed control without crop damage.

In these cases, the time available for experimental work would have been much better spent on simple observation trials to gain experience of the response of individual crops and weeds. After all, it is the amount of useful information per unit of effort that should be the yardstick for planning experimental work with herbicides, and efficiency can only be high if some logical sequence for the evaluation programme is recognised.

EXPERIMENTAL PROCEDURE

Phase 1. Exploratory Work

The response of plants to herbicides is influenced by a large number of factors; some can be controlled by the experimenter, others cannot. Some variation in the results of herbicide applications is therefore inevitable and it is obviously important to know the principal factors involved and to have an indication of the size and frequency of variation under field conditions before deciding on the potential usefulness of a herbicide.

In the first phase of evaluation the net should be cast wide so that some idea can be obtained of the importance of the varying conditions likely to be encountered in practice. The aim should be to build up a broad picture of the capabilities of the herbicide for the control of a range of weed species and of the tolerance of different crops; from this, a crude assessment of selectivity and reliability will be obtained, and experience in handling the chemical under a wide variety of field conditions will suggest certain precautions and limitations that would be important in practical usage.

What is required at this stage can be summarised as: (a) a rough estimate of the average minimum dose of herbicide required to control each weed, and the maximum dose tolerated by each crop without serious damage at different stages of development; (b) an indication of the reliability of results and the principle factors causing variation; (c) an indication of the importance of method of application, e.g., drop size and volume rate; and (d) experience in handling the chemical.

In order to gain these indications, the chief requirements of each trial are that a range of doses should be applied and that techniques should be as simple and quick to carry out as possible. It is generally much more important to have a large number of simple trials on typical weeds and crops growing under a wide range of conditions than to attempt perfection in design at a single site. The design of the trials when testing foliage-applied herbicides can at this stage be very simple: say, two blocks, one of randomised plots, and the other of plots treated in order of ascending dose so as to give a better visual impression of the results. Scoring the plots at intervals after spraying is generally a satisfactory method of assessing results and takes very little time. It is essential to keep detailed records

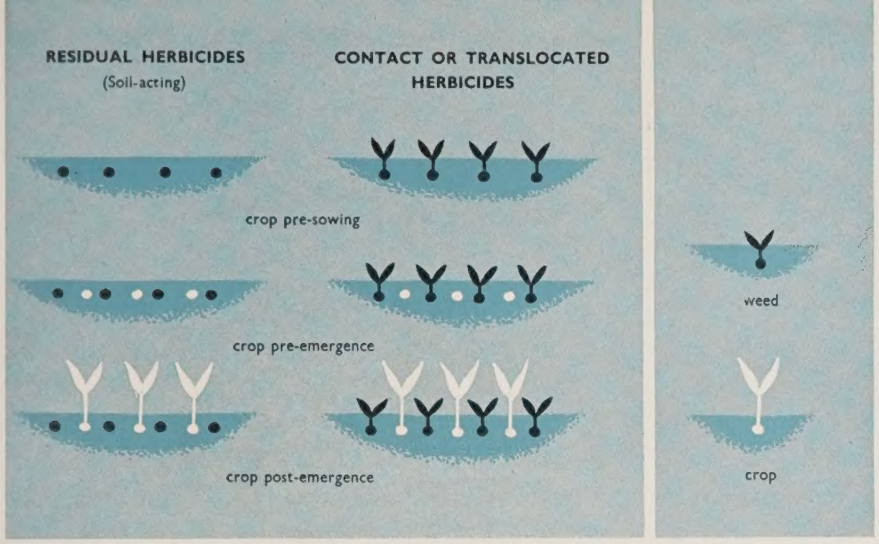


FIG. 1.

The six situations in which herbicides may be used for weed control in crops.

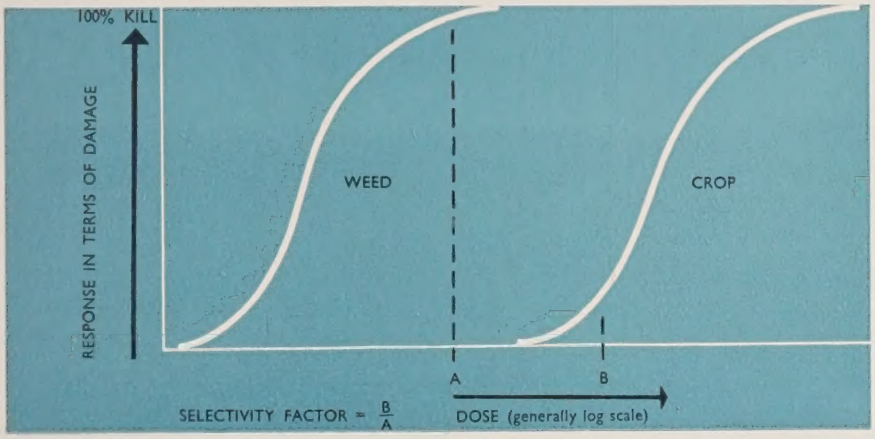


FIG. 2.

Idealised dose response curves for a crop and a weed, to illustrate what is meant by 'selectivity'.

A = Dose for an acceptable level of weed control, e.g. 90% kill

B = Dose for an acceptable level of crop injury, e.g. 0-5% reduction in yield

of the main factors that are likely to affect the results, such as growth stage and weather conditions, in order to enable an attempt to be made to explain any unusual results.

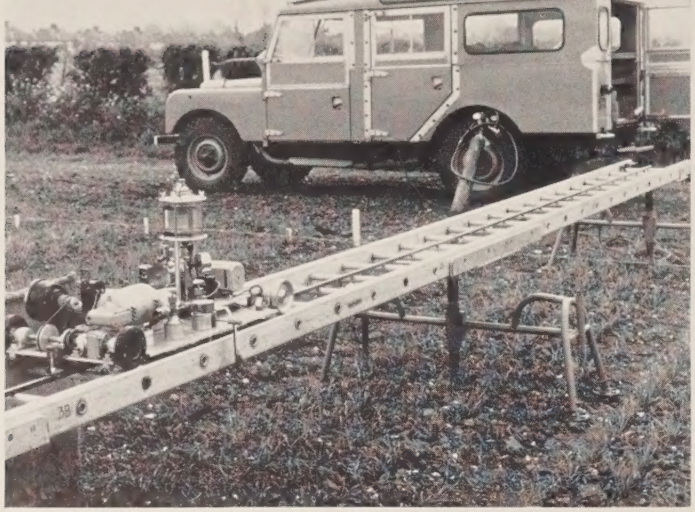
Efficient experimental work can only be carried out if suitable equipment is available. For exploratory work with herbicides, a logarithmic sprayer is an invaluable device which applies in one automatic operation a graded dose range, thereby greatly reducing the labour that would otherwise be required for mixing and spraying individual doses. Various sizes of logarithmic spraying equipment have been constructed, and the choice must be decided by workshop facilities and the type of work to be done with it. For evaluation of a single herbicide, or where space is unrestricted, a large logarithmic sprayer such as that developed at Chesterford Park Research Station (2) is ideal, but where many herbicides are to be tested, and where uniform stands of weeds or crops are limited in extent, much smaller equipment (3) is desirable (*see* illustration of the Oxford Logarithmic Sprayer).

For the accurate application of a uniform dose to experimental plots it is of great assistance to have available specially designed equipment such as the Oxford Precision Sprayer, and the general-purpose field sprayer developed by this Unit in cooperation with the National Institute of Agricultural Engineering (4) (*see* illustrations). Improvised equipment may enable the job to be done but it is seldom efficient or reliable. The importance of having proper equipment for testing herbicides can, indeed, hardly be over emphasised.

Exploratory trials with residual herbicides that are applied to the soil before the weeds emerge cannot be as simplified in design as they can be when treatments are applied after emergence. For instance, it is seldom possible to predict a uniform emergence of individual weed species after application of the treatments, and it is therefore generally desirable to have alternate treated and untreated plots in the experimental design; thus, when the time comes to assess the results by means of weed counts, a clear picture is obtained of the differences in weed population caused by the treatments. Soil type and weather conditions are major factors influencing the results from residual herbicides and this must be borne constantly in mind when making a preliminary appraisal of their uses. The logarithmic sprayer is of only limited use for pre-emergence weed studies as its successful use depends upon a reasonably uniform stand of weeds. For pre-emergence work in crops, however, it can be of great value.

Phase 2. Consolidation

It should be evident from the extensive but simple trials carried out in Phase 1, for which of the principle weeds



The Oxford Logarithmic Sprayer. With this electrically operated equipment the concentration of herbicide is halved each 5-10ft. of run according to jet size, pressure and rate of travel. The plot sprayed is 28ft. long and 3ft. wide. (Photo: National Institute of Agricultural Botany)

The Oxford Precision Sprayer, specially developed for the experimental application of herbicides to small plots, and now in use in many parts of the world. The container on the operator's back contains compressed air which provides a constant but adjustable pressure for spraying.

This general purpose field sprayer for experimental work with herbicides has been in use at Oxford during the last six years. Three pumps and spray-circuits are operated independently from the power take-off to allow rapid changes of volume rate or pressure. Four 20gal. tanks are built into the machine. There is a large range of adjustment of the spray-booms. This machine is particularly valuable for the 'mass production' of similar experiments.

and crops the herbicide under test is most likely to be suitable, and what important factors require further study. Enough information should have been obtained also to allow selection of an appropriate dose range for most situations. There still remain, however, the tasks of consolidating the information obtained so far on the tolerance of the selected crops and the susceptibility of certain weeds, and of investigating other problems shown to be important in the earlier work. Some crops may have been found to be obviously resistant, and some weeds very susceptible, while others may have been more marginal in their response. It is the latter that now require particular attention.

Crops. Before a selective herbicide can be recommended without reservation for a particular crop, it must be demonstrated that when applied at a sufficient dose to control the weeds it does not adversely affect the yield or quality of the produce to an unacceptable extent. It is often not appreciated that the testing required to do this must, if possible, be carried out on crops that are virtually free of weeds (5). It may not otherwise be possible to determine whether an apparent lack of effect on crop yield is a true indication of the safety of the treatment or whether it is the combined result of benefits from weed control on the one hand and crop damage caused by the herbicide on the other, both cancelling each other out.

For example, if weeds capable of reducing the yield of a crop by 10 per cent. were eliminated by a herbicide before any competition with the crop had taken place, the herbicide itself would have to reduce the yield of the crop by more than 10 per cent. before the yield results showed it to be injurious (assuming, of course, that there were no visible symptoms).

In this phase of testing herbicides, yield trials on weed-free crops are the main requirement to determine the maximum safe dose under different conditions. If it is impossible to find weed-free crops, the experimental design should include weeded as well as untreated control plots. Sites must be chosen with care for uniformity, the optimum size of plot selected with reference to the spraying and harvesting techniques to be used, and attention must be given to the accurate application of the chemical and the assessment of yield and quality. Three to six replications are generally required. All means available should be used to increase the precision of the results, since lack of yield reduction is evidence of the safety of the treatment only if the results, on analysis, are shown to be sufficiently accurate to distinguish with significance a reduction of, say, 5 per cent. compared with control.

The main variables to study are growth stage, crop variety, method of application and weather conditions—and also the effect of soil type in the case of residual herbicides. If possible, a number of experiments of similar design should be carried out at different sites in order to obtain an indication of the reliability of the results. This is particularly important in the case of residual herbicides, the successful use of which depends to a great extent on a knowledge of the persistence of the chemicals in the soil. Some evidence can be obtained from field studies, but a combination of field and laboratory work is more satisfactory. Soils that have been treated in the field can be sampled at intervals, and the residue of chemical

remaining can be assessed by means of bioassays carried out in the laboratory.

Weeds. The exploratory work of phase 1 will have indicated which weeds are likely to be controlled by the herbicide being tested, but except in the case of the most susceptible or resistant species, further work will still be required to discover the best way of using the herbicide. Growth stage, time and method of application, effect of crop competition and combination of cultural and chemical methods may all require study. Perennial weeds are often the most difficult to control and some knowledge of the life-history and morphology of particular species may have to be acquired before much progress can be made.

Techniques for studying the effect of herbicides on weeds are still very much in the melting pot—as they are bound to be with the vast array of weed problems to be tackled. The best advice to the experimenter is, perhaps, that he should think clearly what information he is seeking before deciding on the types of experiment and techniques he should adopt. Once again, the logarithmic sprayer will be found to be invaluable for many kinds of weed investigation.

Phase 3. Integration and new Techniques

All the evaluation work described so far has been aimed at finding out the effect of herbicides on individual crop and weed species, the dose-response relationship, and the effect of the more important factors influencing the results. The stage should now have been reached when the experimenter can, with some confidence, make recommendations for the practical use of the herbicides under test in a variety of crop and weed situations. By now, results in terms of weed control and lack of crop damage should be more or less predictable, and a commercial firm should be able, with confidence, to place a new herbicide on the market.

Much, however, may still remain to be done if the herbicide is to play its maximum part in the economic production of crops. Chemical methods of weed control are only justified if they are cheaper, more efficient or more convenient than hand or mechanical methods, or than the practice of what is generally called 'good husbandry'. Experiments to study the merits of chemical versus other methods of control will be high up on the list of evaluation work, but there is another and more important aspect to be considered.

A chemical method of weed control can be regarded simply as an alternative to cultivations or as a replacement of some other traditional method—but it may well be much more than that. If crops can be grown free from weeds, then many of the reasons for traditional cropping systems may no longer be important. For instance, as a result of the existence of herbicides, cereals can now be grown without a build-up of weeds, and there is no longer the need to grow root crops to clean the land after a run of cereal crops. An efficient chemical method of weed control in sugar beet or potatoes would enable these crops to be completely mechanised. Grassland can, for the first time, be reseeded without the use of the plough now that herbicides have been developed which can kill grass swards. These are a few examples of the more far-reaching aspects of herbicide evaluation—aspects that require specialised and imaginative experimental work following on the more routine testing of phases 1 and 2. The experimental techniques required will, of course, be as diverse as the problems themselves.

Conclusion

At the present time there are about 120 chemicals that may be classed as practical herbicides, and although many of these are seldom used nowadays others are being added to the list each year. Some indication has been given here of the channels along which thought and action must flow during the process of field evaluation, if new herbicides are to play their maximum part in the economical production of crops.

The task of field evaluation, not only in respect of crop production, but for the many other uses of herbicides, is a real challenge to those who have the time and facilities to get to grips with it. To those who have to test herbicides as only a minor part of their duties, the task can be irksome and unsatisfying, not only because, through lack of knowledge and experience, the results of their work are often so disappointing, but also because they may be unable to see how the results that they obtain fit into the scheme as a whole.

It has only been possible here to outline superficially the principles adopted by the weed research team at Oxford in their approach to this complex and intriguing subject, and much has been omitted: there is far more to the field testing of herbicides than has been indicated in this article.

Chemical weed control is a subject which touches on many aspects of science and technology, and field work is only part of the long process which separates the first discovery of any active chemical from its ultimate application on the farm. If the greatest use is to be made of herbicides, the utmost cooperation is required between the scientist, agronomist, engineer, manufacturing and supplying industries and official regulatory and advisory services. The weed control specialist holds the key to this cooperation by his understanding of the many and special problems involved. Progress must to a large extent depend on his ability to bring together the other specialists, to stimulate their interest and to apply their combined knowledge and experience to weed control problems encountered in the field.

REFERENCES

(1) Fryer, J. D. Some principles underlying the field testing of selective herbicides. *Proc. 1st African Weed Control Conf.* (in press).

(2) Hartley, G. S., Pfeiffer, R. K. and Brunskill, R. T. The Chesterford logarithmic sprayer. *Proc. 3rd Brit. Weed Control Conf.* 571-584, 1956.

(3) Fryer, J. D. A small scale logarithmic sprayer. *Proc. 3rd Brit. Weed Conf.* 585-590, 1956.

(4) Fryer, J. D. and Elliott, J. G. Spraying equipment for the experimental application of herbicides. *Proc. 2nd Brit. Weed Control Conf.* 375-388, 1954.

(5) Woodford, E. K. Experimental techniques for the evaluation of selective herbicides. *N.A.A.S. Quart. Rev.* **2.** 1-10, 1950.

The main entrance to the fair.

WORLD AGRICULTURE FAIR

Shell International Chemical Company's pavilion, which comprised 12 bays each devoted to the damage caused by insects and diseases to a specific crop. An illuminated map (below the flag pole) showed the world-wide location of Shell Companies, research stations and technical service laboratories. The pavilion was awarded first prize in the plant protection section of the national sector of the fair.

The striking entrance to the USSR pavilion. In addition to demonstrating every aspect of Soviet agriculture, the exhibit included a model of Sputnik II.

The Madras State pavilion, which was designed on the lines of the Hindu temples commonly found in this State and throughout southern India.

India Today: many aspects of modern India apart from agriculture were illustrated in this pavilion, which was concerned with achievements, current conditions and future plans.

Orissa, one of the smaller Indian States, was represented by this impressive pavilion. Local irrigation schemes and crop varieties were among the many exhibits.

Entrance to the USA pavilion. This comprehensive exhibit included demonstrations of genetic research and of the manufacture and use of radio-active isotopes in agriculture.

For more than two months recently New Delhi was the scene of an unusual and impressive spectacle in the shape of a World Agriculture Fair. Opened in December, 1959, by the President of India, Dr. Rajendra Prasad, in the presence of President Eisenhower and India's Prime Minister, Pandit Nehru, the fair attracted nearly four million visitors. It had been staged by the Indian Farmers Forum (Bharat Krishak Samaj).

Fourteen countries (including the USA, USSR and China), all the Indian States, and a number of industrial and commercial concerns (including Shell International Chemical Company) exhibited at the fair, and, as these pictures show, many of the pavilions were of remarkably striking design.

Each national pavilion demonstrated the agriculture and produce of the country, and some countries also exhibited agricultural machinery and other products for export. The Indian pavilions depicted agricultural methods and progress in the different States. Large sections of the exhibition were devoted to crop protection, fertilisers and agricultural machinery. The work of different government departments, notably those responsible for dairying and livestock, irrigation and power, fisheries and crop protection, was illustrated by various impressive exhibits.

The proper use of fertiliser in tropical agriculture helps to produce good crops such as these. The sugar cane is being harvested in Eastern Java, the coffee is growing near Campinas, Brazil, and the tea in Southern India.

FERTILISERS IN TROPICAL AGRICULTURE

by **Ir. J. G. de Geus,** *Centraal Stikstof Verkoopkantoor, N.V., The Netherlands*

According to FAO figures world fertiliser consumption in 1957/58 amounted to:

7,257,787 tons N;
8,097,892 tons P_2O_5;
6,748,588 tons K_2O.

If we compare fertiliser consumption in the main temperate areas with the use of fertilisers in tropical and subtropical areas, we see that by far the greater part is used in the temperate areas, as illustrated by the following figures:

Fertiliser consumption in three of the main temperate areas

	N (tons)	P_2O_5 (tons)	K_2O (tons)
Europe ..	3,293,321	4,174,627	4,221,030
USA	1,967,000	2,063,400	1,603,900
Japan	635,840	333,840	387,900
	5,896,161	6,571,867	6,212,830

Fertiliser consumption in tropical and subtropical areas

	N (tons)	P_2O_5 (tons)	K_2O (tons)
Central America and Mexico ..	268,064	82,230	80,544
South America	131,888	158,534	91,141
South and South-East Asia ..	319,839	55,863	67,750
Africa	254,236	304,790	72,529
	974,027	601,417	311,964

This difference in fertiliser consumption is certainly not due to the fact that tropical soils require less fertiliser because of a naturally higher fertility level.

Tropical Soils

Tropical soils, and particularly the lateritic type of tropical soils, may be very poor because climatic conditions, culminating in high temperatures and heavy rainfall, intensify the weathering process so much that tremendous amounts of bases and other plant nutrients are lost by leaching and hardly anything is left. In the final stage of lateritic weathering the soil consists of little more than iron and aluminium. The lateritic soils are mostly very poor in plant nutrients, therefore, but very responsive to fertilisers, the more so as their favourable physical condition guarantees a good fertiliser response.

In other cases, fertiliser requirements are due to the fact that soils have been cultivated from time immemorial, and that enormous quantities of plant nutrients have been removed in crops and by leaching over these thousands of years.

There are some much richer soil types, of course, particularly in volcanic areas where each eruption means a new supply of fresh material often relatively rich in plant nutrients such as phosphorus, potassium, calcium, magnesium, etc., but even these soil types are much in need of nitrogen because this element is not provided for by volcanic activity.

Young volcanic soils are mostly very responsive to nitrogenous fertilisers, therefore, because the favourable situation relating to the other nutrients forms a sound background for a good nitrogen response. Many of the older soil types, however, cannot do with nitrogen alone, but need also phosphates, potash and eventually other nutrients.

The natural forest cover of tropical soils is a very important factor in maintaining soil fertility, especially for older soil types that have lost the greater part of their original nutrient reserve. The remaining nutrients are protected from leaching not only because large quantities of nutrients are temporarily tied up in the trunks and branches of trees, but also because of a kind of accumulation process whereby nutrients are taken up from the subsoil and accumulate in the topsoil as a result of leaf-fall and leaching from the leaves. If those forests are cleared and the area cultivated, the soils seem to be very fertile because crops develop and yield well as a result of this nutrient accumulation. But especially under conditions of careless management this nutrient reserve may be exhausted within a few years and the final result is a very poor yielding soil, in spite of its originally promising prospects. Apparently well developed forests may be found on basically very poor soils, therefore, and should not be considered indicators of a high soil-fertility level.

Summarising, we may say that most of the soils in tropical and subtropical areas are much in need of fertilisers if they are to reach satisfactory yield levels.

Shifting Cultivation

Shifting cultivation is a type of cultivation method best adapted to the plant nutrient accumulating tendency of a natural forest cover. It is still fairly extensively practised by the indigenous population in many parts of Africa. In this case a forest plot is cleared, all wood is burned and the plot is planted for a couple of years with food crops such as rice, maize, sweet potatoes and cassave. These crops gradually exhaust the available stock of accumulated plant nutrients and often the first to be planted, the most-exacting crop, rice, is therefore followed by maize and

later by the less-exacting root crops such as sweet potatoes and cassave—crops that may succeed in obtaining their nutrients from somewhat less available forms.

The plant nutrient reserve is now more or less exhausted, food crops no longer grow and the population moves on to another forest area which is cleared, and where the same process starts. The original abandoned forest plot is left uncultivated and here gradually develops a new forest which starts to accumulate a new stock of plant nutrients that may be utilised in due course; after a period of several decades people may return to this original plot to reap the temporary soil fertility built up by the forest vegetation.

This system works quite well as long as population is not dense and forest areas are plentiful so that each cleared forest plot gets a sufficient number of years afterwards for complete restoration. But as soon as population becomes relatively too dense, and the forest areas do not have enough rest for the new build up, the system does not work any longer and an efficient fertilising scheme is the only solution for obtaining good yields from impoverished soils. So, while for densely populated countries like India, fertilisers are the backbone of all the measures required to solve the food problem, in Africa, too, there is a rapidly increasing need for fertilisers.

Coffee in Brazil

Up to now, coffee-growing in Brazil has also been a kind of shifting cultivation. After clearing the forest, coffee was planted. Owing to the reserve in plant nutrients present at the time of clearing, the young trees started off quite well, developed promisingly and showed good yields for a number of years. Thereafter, however, the trees deteriorated and yields became lower and lower. The reason was that the plant nutrient reserve became exhausted and that these soils have no mineral reserve that can provide a new supply of nutrients as a result of weathering. Deterioration was accelerated by the fact that the soils were exploited and exhausted without paying any attention to soil conservation and to preservation of the valuable nutrient reserve.

Because so much suitable land was available coffee-growing simply moved on to a new area as soon as yields became so low that the old plantations were considered uneconomic, and here the sad story of soil ill-treatment started anew, resulting after a number of years in a further move. Now, however, this policy of moving on to virgin soils when the old ones become exhausted cannot be continued because there are hardly any soils left suitable for coffee-growing under favourable climatic conditions. The only solution, therefore, is to concentrate on a more permanent type of coffee-growing in areas where soil and climate are considered best, and to meet the heavy demands of the crop by effective soil conservation measures and a judicious fertilising scheme.

Less Shade—More Fertilisers

The need for fertilisers is increased by the fact that in Brazil coffee is grown without shade and unshaded coffee requires more fertilisers—and in particular more nitrogen—because:

1. The production level of unshaded coffee is generally higher than for shaded coffee due to the fact that shade reduces flower initiation and consequently yield;
2. Unshaded coffee has to do without the nitrogen resulting from the organic matter supplied by the shade; and
3. For many plants, nitrogen requirements are higher as the quantity of light increases.

For this reason unshaded coffee often needs at least 200lb. N per acre, whereas for shaded coffee the optimum amount is seldom higher than 120lb.

The ripening process of a heavy crop results in such a strain on the trees that they may suffer seriously from overbearing and die-back, which are symptoms of exhaustion, a condition to be controlled by heavy fertiliser applications—particularly nitrogen and potash.

As reduced shade means a higher yielding capacity, there is a tendency also in other coffee-growing areas to reduce shade and to use more fertilisers.

Cocoa and Tea

The same rule holds true for two other crops—cocoa and tea. For cocoa, shade plays the same role as it does for coffee: it reduces flower initiation, thus decreasing production capacity. The modern trend, therefore, is for high producing clones, strongly reduced shade and a judicious fertilising scheme well adapted to this new shade policy. Young cocoa, however, needs shade that can be reduced as trees grow older.

The removal of shade in tea-growing was greatly stimulated by the outbreak of blister blight, because sunlight is one of the most effective indirect control measures for this disease. This removal, or drastic thinning out of the shade, resulted in much higher fertiliser requirements, particularly nitrogen. Adequate fertiliser to keep the bushes in good and healthy condition is not only important from a production point of view, but it is also a main factor in restricting the damage done by blister blight. For this crop, each pound of N may be interpreted as 5-8lb. of extra tea and for a healthy, productive plantation at least 120lb. N per acre per year, well balanced with P and K, should be considered a good indication of the fertiliser requirement.

Commercial Crops

In many cases by far the greater part of all fertilisers used in tropical and subtropical countries is applied to commercial crops. In Indonesia, for instance, practically all the fertilisers (sulphate of ammonia, double superphosphate, rock phosphate and potash fertilisers) are used for sugar cane, tea, rubber, oilpalm, tobacco, potatoes, cabbage, onions, etc., with only a relatively very small amount for typical food crops such as rice, maize, cassave and sweet potatoes.

In Thailand, fertiliser is so far mainly consumed in the vegetable and fruit growing area around Bangkok;

practically no fertiliser is used on rice (not only the most important food crop of the country but also the most important crop from an economic point of view, accounting for about 60 per cent of the country's exports). It should be noted further that most of these rice soils are rather phosphate-deficient and also that nitrogen shows a good response as soon as the phosphate requirements of the rice plants are fulfilled.

In India, too, quite a substantial part of the fertiliser used finds its way to commercial crops and in the *Report on India's Food Crisis and Steps to Meet it*, sponsored by the Ford Foundation and issued by the Government of India (April, 1959) we even find it remarked 'that an undue proportion of scarce fertilisers last year went to non-food crops, and to sugar cane', in which connection it is stated that fertilisers should be allocated primarily to growers of food crops as long as they are in short supply.

One should always realise, however, that commercial crops utilise fertilisers because fertilising is a paying proposition from a commercial point of view. This means that every pound or dollar spent on fertilisers is paid back manifold. In fact, for most crops profits are very closely correlated to the amounts of fertilisers used, because fixed costs, such as soil tillage, seedbed preparation, planting or sowing and cultivating the land are about the same whether yields are low or high. The difference between low and high yields, however, and so the profit, is determined by the judicious use of fertilisers. Without fertilisers commercial crops will quite often produce no profit at all, and they may show a loss. Profitable growing of sugar cane is practically impossible without fertilisers and particularly without nitrogen. The same holds true for most other commercial crops.

No problems can be solved, therefore, by decreasing the amount of fertilisers on commercial crops. On the contrary, as plant breeding results in higher yielding varieties, more fertilisers will generally be required to realise the higher yielding capacity of these new varieties.

Tropical Food Crops

Relatively, very little fertiliser is used on food crops in tropical areas so far, and this in spite of the fact that several countries have a tremendous shortage in food grains, and in spite of the fact that home production could be increased considerably by the use of fertilisers.

Indonesia, for instance, imports 500,000 tons of rice or more a year to meet her needs. On the island of Java, more than two million acres have proved to be phosphate-deficient and by the use of phosphate fertilisers it should be possible to increase home production and thus reduce the large quantities of rice imported annually.

Ceylon imports most of her rice requirements, but domestic production might well be increased, as in experiments 50-100 per cent yield increases resulted from nitrogen applications, supplemented with phosphate and potash where necessary.

In Pakistan, another food-importing country, trials on Government farms showed an average response of 15-20lb. of wheat and 18-22lb. of rice per pound of nitrogen, which means that here, too, nitrogenous fertilisers could contribute considerably to a higher production level.

In the *Report on India's Food Crisis* it is stated that by 1965/66, 110 million tons of food grains will be necessary for India's rapidly rising population, for some dietary improvement and for a safety margin for poor crop years and emergency conditions; whereas at the present rate of production increase total production by then would be 82 million tons, thus leaving a gap between production and requirements of 28 million tons. The rate of production increase must be trebled, therefore, to meet this target, and next to irrigation, bunding, improved seeds and other facilities, the following quantities of fertilisers are considered necessary:

1,500,000 tons N;
750,000 tons P_2O_5;
200,000 tons K_2O.

So there is tremendous scope for fertiliser use on food crops in tropical and subtropical areas, though to realise these possibilities many problems will have to be solved. The main problems are the need for easy and cheap credit on behalf of the poor, small subsistence farmer, the need for stabilisation of farm prices, breeding of high-yielding crop varieties more responsive to fertilising, better water management and improved cultural practices to offer the best possible background for a good fertiliser response.

A great stimulus for increased fertiliser use is irrigation. Irrigation is a rather costly affair that only pays if other production factors, including judicious fertilising, are also made full use of.

In rice growing, promising hybrids have been developed from *Indica japonica* crosses which have stiffer straw and show a better response to high fertility levels than the local *Indica* varieties. For the latest higher fertiliser applications often tend to show up more in a relatively too strong vegetative development than in increased yields.

The importance of improved cultural practices for a good fertiliser response is demonstrated by the fact that the response of a certain amount of fertiliser is often much more pronounced on experimental farms than in the cultivator's fields, just because soil tillage, seedbed preparation and other cultural practices were better on the experimental farms.

Summarising, we may say that our expectation for a rapid increase of the fertiliser used in tropical and subtropical areas is based on five considerations:

(1) The generally low fertility level of tropical and subtropical soils;

(2) The fact that, as a result of increasing population density, shifting cultivation is no longer possible in many areas where in one form or another it has been practised so far;

(3) The tendency to grow crops such as coffee, cocoa and tea without shade;

(4) The necessity for a judicious fertilising scheme for profitable growing of commercial crops;

(5) The shortage of food grains for many tropical countries and the possibilities of much higher yields by increased fertiliser use.

The Agriculture of South-East Asia

by **J. M. Brown,** *The Shell Company of the Federation of Malaya.*

In a region where the mass of the people live by the rice bowl, cultivation of the staple cereal is still extensive rather than intensive: yields have altered little over the last 20 years. Apart from a relatively small number of large estates, subsistence agriculture is still the rule. In South-east Asia, in the compact ring of countries which enclose the South China Sea, from Burma to the Philippines, bounded by Java in the south, one-sixth of the world's population produces nearly nine-tenths of the free world's supply of natural rubber, the important export markets being Europe and the USA. One-third of the world's production of palm oil, used in the manufacture of soaps, margarine, and cooking oils, comes from Malaya and Indonesia. In addition, the region makes useful exports of rice to India, China and Japan.

Populations are increasing at record rates—in Singapore at 3½ per cent. per year. There is land hunger, but land utilisation is low. South-east Asia is as yet underdeveloped. Situated almost entirely within the humid or wet tropics, this area has properties which have led to its being described as the New World of the East, the natural target for immigrants from the vast land masses, India and China, which overshadow it. These properties will be described below.

The land-forms of South-east Asia are mountainous, in places volcanic, and plentifully supplied with complex river systems. The natural vegetation is tropical rain forest, or jungle. High rainfall, combined with the clearing of upland areas for cultivation, have resulted in considerable erosion, assisting the formation of fertile alluvial flats and broad river deltas. Early European estate practice of exposing bare earth during clearing and planting, and of clean-weeding the entire inter-row area during the establishment period, contributed further to this erosion: thus, though harmful to the estates themselves, this process was not without its good effects.

Agriculture is now practised on cleared rolling uplands and the deltaic plains. Soils, subjected to conditions of consistently high warmth and moisture, are fiercely leached and weathered. Cleared upland soils are harsh and inherently low in fertility. Humus is rapidly exhausted. The climate of the area varies from monsoonal, in the north, with recognisable cool dry and warm wet seasons, to equatorial, with heavy rains throughout the year.

In the important crop-producing countries, the area under forest ranges from one-quarter of the total land area in the case of Java, which has easily the highest population density (and consequently the greatest pressure to clear the land for agriculture), to Burma and Malaya, where the areas under forest are one-half and four-fifths respectively. An interesting variation of the tropical rain forest is the monsoon forest, where one species frequently becomes predominant. An important example of this is the valuable teak forests of northern Burma and Thailand, eastern Java and the Moluccas. However, this is the exception. The true tropical rain forest contains an enormous number of different varieties of trees, thereby creating a paradox. In countries which abound in forest trees, the

foundation of timber industries is often a problem, owing to the difficulty in locating, in a given area, a sufficient number of trees of any one variety.

Three Types of Land

South-east Asia contains three main types of agricultural land: first, the relatively arid areas or areas where the rainfall is irregular, such as northern Burma and northern Thailand. Here there is little scope for rice, and dry farming must be practised, maize, sorghums, millets, groundnuts and pulses being the most suitable field crops. Then there are the relatively limited irrigated areas, which can grow any crop; and thirdly, the more extensive areas of plentiful rainfall, but no drainage control, where rice and fish are cultivated in the areas adjoining rivers. Estate crops are mainly grown in the upland districts of the last-named areas.

With the exception of sugar and tobacco in the Philippines, and tea in Sumatra, estate crops are almost all tree crops, rubber, oil palms, coconuts, etc., since the natural conditions of the humid tropics favour tree growth, corresponding to the indigenous rain forest. In general, commercial farming and the production of export crops are not highly developed. Although the area is a net exporter of rice, the main exports being made by Burma, Thailand, Cambodia and south Vietnam, rice is imported into the area from South America.

Over the whole area, more than two-thirds of the native sedentary farming is devoted to subsistence farming, of which more than 90 per cent is occupied with rice production, the remainder with coconuts, fruits, spices and pulses. Half the total area of export crops is devoted to rice; the remainder is mainly under tree crops cultivated by estates and, to a much lesser extent, by native smallholders, each holding being only a few acres in size. Some estates, as in the Philippines, Java and Sumatra, are Asian owned, whilst others, as for example in Malaya, are still financed by foreign capital, making in their turn a useful contribution to the export earnings of the country where they operate.

Rice

Rice is grown by time-honoured systems and yields are low compared to these obtained in other parts of the world. Traditional laborious methods of hand cutting and harvesting are employed, with, in some areas, the use of water buffaloes for ploughing. Elsewhere, the mattock or changkol is the principal tool. Padi planters throughout the area are extremely conservative; thus, in some parts, reaping of the padi is held to be an exclusively male occupation and each handful of padi is cut separately with a small hand-knife—sometimes with the handle shaped like a bird, because it is believed that only if the crop is reaped in this way will the succeeding crop yield well. Immigrant Chinese padi planters have shown themselves to be quickly amenable to new, improved methods, but native cultivators generally resist change.

Even where the farmer can be convinced that more modern methods are better, a barrier is likely to exist in his lack of funds to adopt the new system. His harvest is usually sold to middle-men or millers. It is common for the farmer to borrow money during the growing season, for a wedding, a festival, or a genuine emergency. By harvest time he is heavily in debt and must sell his produce at a debased price.

Heavy indebtedness, high rentals, a high population density in the padi areas, resulting in over-fragmented holdings, characterise the agrarian structure throughout South-east Asia. Fertilisers are used, but any new system of cultivation involving the use of greatly increased quantities of fertilisers, insecticides or mechanical methods, is beyond the immediate reach of all but a few. There is scope for the introduction of a mechanical cultivator similar to those in use by market gardeners in other parts of the world, but the initial cost would be prohibitive to most. An almost unanswerable argument in favour of traditional methods comes in here: the ox and the buffalo will reproduce themselves—and, in addition, produce manure.

Even in the famous delta regions of the Irrawaddy in Burma, the Chao Praya in Thailand and the Mekong river in Cambodia and south Vietnam, which produce the bulk of the region's export of rice, cultivation of this crop is still extensive and not intensive, being dependent almost entirely on rainfall, on the flood level of these rivers reaching a certain mark. Otherwise planting may be delayed to the point where subsequent tillering is affected. In Cambodia, between 80 and 90 per cent. of the padi is rain-fed and 100 per cent. variations of yield in successful years are possible; whilst in Vietnam, the chances of a good crop are one in three.

Crop Research

Government Departments of Agriculture throughout the region have set up numerous padi experimental stations. Here, improved high-yielding, stiffer-strawed varieties are being bred. Response to fertilisers and the system of using two top dressings, as well as the use of insecticides, is being studied. Double-cropping is only possible at present in relatively small areas where water levels can be reliably controlled; however, Japonica varieties, which respond well to fertilisers, and which are quick-maturing and non-photosensitive (so that they may be grown independently of season, and hence double-cropped) are being studied. Work is also in progress on the effect of crossing these with the photosensitive, slower-maturing, single-crop Indicus varieties now in general use. Efforts to promote the use of insecticides are handicapped by the fact that several of the more effective insecticides are toxic to man, or to the fish which are frequently cultivated in padi waters.

One principal function of Department of Agriculture stations, in the padi as well as upland areas, is the vegetative propagation of selected stocks and their sale to farmers at subsidised prices. Besides padi, there is a ready sale of fruit stocks of all kinds, rubber, etc. This marks another development, for although there is need to expand rice production, padi is no longer planted as a matter of course and farmers may be more readily attracted in

Tapping rubber: a high double cut. The old tapping panel can be seen below, with the final cut revealed as a transverse black line at the base of the tree.
(Photo: Rubber Research Institute, Malaya.)

Kelantan (East Coast, Malaya) fishermen hauling in nets.

future to commercial production of fruit and plantation crops. Already, as a result of the post-war shortage of rice, a marked taste has developed for the products of flour from imported Australian wheat. As standards of living rise and tastes become more westernised, padi cultivation may not occupy in years to come quite the same position of paramount importance that it does today.

Tree crops, once established, provide a steady income with comparatively small labour requirements, but eventually, for small farmers, replanting becomes a problem. In Malaya, this is overcome by the Government-sponsored Rubber Replanting Board, which is financed, like the Rubber Research Institute of Malaya, by a small cess on the export of rubber and offers an acreage grant for replanting. With this scheme also, under certain conditions, rubber lands may be replanted with oil palms, tea, coffee, and other desirable crops.

Market gardeners cultivate vegetable gardens near main towns. Their methods are intensive, making good use of composted manure, fertilisers and, frequently, modern insecticides. In the future, this type of cultivation could become more general in South-east Asia.

Fish Culture

Rice is, of course, the staple food. Next in importance is fish. It is the chief source of protein and minerals in Asian diets. In spite of their low salinity and oxygen content, the seas surrounding the extensive coastlines of South-east Asia are plentifully stocked with fish, which are fished intensively, then salted or dried to withstand storage under tropical conditions.

Inland fisheries are of three types: natural streams and pools, stocked with indigenous fish; irrigated and drainage-controlled padi areas, stocked by man with fish of medium productivity; and pools artificially stocked with fish of medium to high productivity. In the last-named class, a perfect biological balance is often maintained by native farmers. A piggery is situated at the side of a pond, and ducks are kept on the pond. Liquid manure from the pigs is encouraged to drain into the pond. This and the droppings from the ducks assist in the production of algae and other plant food which feed the fish, and also manure water hyacinths which grow on the surface. Roots of the water hyacinths are fed to the pigs. Manure from the pigs helps to produce grain, which is fed to the ducks. The fish are caught for food.

Most of the countries in the region have fish research stations. One of the most modern of these is the recently constructed Fish Culture Research Station at Malacca, in central Malaya, built and financed by funds supplied by the UK. Improved strains are being studied, the most promising being *Tilapia mossambica*, which originates from Mozambique, and was taken from a single pond in Java to Singapore by the Japanese during their wartime occupation; from there it has spread to most countries of South-east Asia. It is hoped that *Tilapia* can replace Chinese carp, at present the most productive pond species, but which will not breed outside China, so that the importation of fry is expensive.

One promising line of research is the application of artificial fertilisers to fish ponds, in order to stimulate the growth of aquatic plants and algae. Spectacular results have been obtained and it has been shown to be easily possible to produce yields of more than one thousand

A Thai padi farmer.

A Chinese vegetable farm in Malaya.

pounds of fish per acre per annum by this means. In Malaya, it is hoped to carry out scientific stocking of the many mining pools produced by tin dredging, for many years a major industry.

Cultivation of animals for meat or milk is small. Buffaloes are kept for milk, largely for the farmer's own use. Water buffaloes, bullocks, and oxen in the north, are bred as draught animals; but apart from these types, which are naturally suited to the conditions, imported high-yielding animals are not suited to the local climate, vegetation and pests. There are in addition religious factors affecting livestock production, since Buddhists and Hindhus will not eat beef and Muslims will not eat pork.

Need to Increase Production

A feature of the entire area is the pressure which is now being placed on the small farmer, mainly the subsistence farmer, to raise his yields. To understand this pressure, it should be realised that originally the terrain, the climate and the generally unhealthy conditions of South-east Asia, which consisted of coastal swamps and dense jungle, were not such as to attract immigrants. Under the influence of the colonial powers, Holland, France, Britain and, for a period in the Philippines, the USA, health services and communications were provided and land was cleared for the cultivation of plantation crops, exports of which brought prosperity to these countries. At this point, Chinese and Indian immigrants arrived to take over the functions of shopkeepers, merchants and middlemen.

What has happened since the Second World War is that the impact of Western ideas on a static Eastern society—which formerly consisted of a tiny ruling class and a mass of people engaged in, and contented with, subsistence agriculture—has resulted in the creation of a large Asian middle class.

The influence of this has been seen in the political events of recent years. Moreover, this development has produced the need to increase standards of living in order to support this growing new society. In seeking political and industrial development, governments must first generate prosperous conditions by means of trade. For the countries of South-east Asia, this means influencing the native farmer to produce an exportable surplus of agricultural products, derived from the production of cash crops, or surpluses of the subsistence crops.

It must not be thought that the native farmers are entirely opposed to modern methods. The need for artificial fertilisers is universally recognised, whilst ever-increasing use is being made of improved plant stocks. If modern insecticides are not more widely used, it is because of their cost; although in the Philippines and Java, for example, as well as on vegetable farms in other countries, their use by small farmers is fairly common. In their efforts to raise native production, Governments may be obliged to subsidise the use of insecticides. Extension work is reasonably well developed, especially so in the Philippines and also in Indonesia. Elsewhere, the nucleus is there, but in the main, the need is for more workers who are sympathetic and knowledgeable enough to gain a hearing from the farmers.

Use of Chemicals

Estates have access to the most modern methods, receiving technical advice from their parent companies, who some-

times maintain their own local research centres. Rubber is well provided for by such bodies as the Rubber Research Institute of Malaya, L'Institut des Recherches sur le Caoutchouc en Indochine, and others. Estates make good use of insecticides and oil palms have been aerially sprayed (with endrin) against bag-worms, and (with dieldrin) against other lepidopterous pests. Similarly, tea thrips and mosquito borers (*Heliothis*) have been controlled (with dieldrin) in Sumatra and termites attacking the root systems of trees have been controlled (with aldrin) in several countries.

Chemical yield stimulants (based on 2,4,5-T and 2,4-D), have been used on rubber, whilst considerable quantities of weedkillers (sodium arsenite, dalapon, 2,4-D and 2,4,5-T) and chemical treekillers (sodium arsenite and 2,4,5-T) have been used. It is interesting to note that 2,4,5-T, which was first developed as a hormone weedkiller, is used at low concentrations to stimulate yields of the rubber tree, whilst the same chemical at higher concentrations kills the tree. In doing so, it stimulates the yield in a manner which is exhaustive to the tree and assists its kill, and this additional heavy yield becomes a bonus to the owners of the estate.

Technical and Economic Aid

In terms of technical and economic aid, various international agencies have been active. FAO (Food and Agriculture Organisation of United Nations) has sent experts to work with governments in the study of farm management, flood control, improvement of plant strains, the setting up of rice training centres, veterinary science, extension work, fisheries development and other subjects. ICA (International Cooperation and Administration) operating with US funds, has subsidised the import of equipment, fertilisers and insecticides. Individual governments, for example those of the UK and the USA, have provided financial assistance through loans. Under the Colombo Plan, funds derived from released sterling balances and other sources, have been used to improve cultivation, irrigation, drainage and reclamation of land, mechanisation, the use of fertilisers, and the control of pests and diseases. This has provided direct aid of a most valuable kind.

Governments of the countries themselves have been actively concerned with plans for improvement. These have been directed at improvement of cropping methods, expansion of new crop areas, land reform, improvement of agricultural credit, assistance in replanting, land settlement schemes, and the establishment of community development projects. Other measures have included the setting up of state-owned rice mills and padi buying stations, as in Burma, legislation to regulate the marketing of rice, provision of storage facilities, and various subsidies both direct and indirect. In Malaya, the Philippines and south Vietnam, attention is being paid to the development of inland fisheries. The Indonesian Government has begun the clearing of large inland areas of Borneo and the building of polders, with the object of creating a large new padi area.

One method of freeing farmers from the grip of moneylenders, providing credit and assisting with marketing, is by the creation of farmers' cooperatives. In the Philippines and Thailand, numerous cooperatives exist and work well. In other countries, they are being developed, but have not worked so well to date.

Specialise or Diversify?

In seeking to promote exports, countries face a choice between specialisation—on rice, or on the cash crops, oil palms, sugar, rubber, etc., with which the colonial powers originally opened up and brought prosperity to the area—or diversification. At present, the economies of South-east Asian countries are largely geared to specialisation; for example, the prosperity of Thailand is still dependent mainly on exports of rice and rubber; that of the Federation of Malaya on rubber and tin—all commodities whose world prices have shown considerable fluctuation.

The problems of specialisation are disease, for the cure of which the small farmer lacks funds, and susceptibility to market slumps, such as have occurred in the past with rubber and palm oil prices. Those of diversification are lack of capital, together with the modern demand for high quality and standardisation of produce. Moreover, the simple standards of the native farmer can reverse the law of supply and demand. If prices increase, he needs to produce less in order to fulfil his simple wants. In fact, subsistence farming in the area is already diversified, cash farming specialised. The tremendous encouragement which the Government of the Federation of Malaya is giving to rubber replanting is a bold measure and indicates their faith in the future of natural rubber; but even in Malaya, the constant cry is for diversification of the basic industry—agriculture.

In the countries of South-east Asia, the universal desire is for self-sufficiency. This is manifested in the universal wish of each country to possess eventually those two symbols of basic production, the oil refinery and the fertiliser works. In addition, whilst foreign aid is gratefully received, many Asians would rather see the fostering of basic industry, as, for example, the setting up of a sugar industry within their country, than the rebuilding of town centres, desirable though this may be. The pressure of population in the area is still rising and the pressure to raise agricultural production is increasing.

BIBLIOGRAPHY

DOBBY, E. H. G. *South-East Asia.* University of London Press; 5th edition, 1956.

SILCOCK, T. H. *The Commonwealth Economics in South-East Asia.* Duke University Press, USA, 1959.

TEMPANY, Sir H. and GRIST, D. H. *An Introduction to Tropical Agriculture.* Longmans, Green, 1958.

FAO. *Report of the Fourth Regional Conference for Asia and the Far East,* Tokyo, 1958.

J. trop. Geography. **12,** March. 1959.

Testing for Insecticide Resistance

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Experiments with insecticides may have various objectives and the design of such tests should relate to the aim in view. Certain matters, however, are common to most types of experiment and a general acquaintance with the principles of insecticide testing is desirable (*see* BUSVINE, 1957, or SHEPARD, 1958). In most cases, relations between dose and kill are involved and the interpretation of regression curves will be discussed later. But the two primary data, 'dosage' and 'mortality' deserve some preliminary attention.

Dosage. The words 'dose' and 'dosage' are too often used in a vague way, sometimes associated with slipshod thinking. Properly speaking, a dose of insecticide should refer to a quantity of poison administered to an insect. But it is often very difficult to dose individual insects owing to their small size. Therefore, standard quantities of poison are sprayed into their environment or are applied to surfaces on which they are crawling and, after a standard time of exposure, it is assumed that each insect will be contaminated to the same extent. There is nothing seriously wrong with allowing insects to 'dose themselves' in this way; indeed, it is a common feature of many standard tests. But it is important to realise that this introduces another variable into the experiments, independent of the poisoning process itself, and to consider how the dose picked up by the insects may be affected by variation in conditions (especially temperature and crowding of insects).

Mortality Detection. Death in an insect is by no means as easy to detect as in vertebrates, which cannot generally survive for long after the heart and lungs stop. For various reasons, the last stages of poisoning of insects are prolonged and indefinite, so that the last tiny movements of a batch of dying insects may be widely scattered in time. Generally, the actual death point is much less easy to assess than certain earlier stages of intoxication. Suitable criteria are the ability to walk or fly or to cling to paper or cloth. It is best to decide on a particular sign of poisoning and use this for discriminating throughout.

For certain special toxicological investigations, it may be helpful to record the proportions of insects in different stages of poisoning; e.g., 'normal', 'affected', 'moribund' and 'dead'. But this is not desirable in the majority of cases, and certainly not in measuring levels of susceptibility or resistance, as it merely complicates their interpretation. In such work, only two categories are necessary: 'alive' (plus affected?) and 'dead' (plus moribund?).

Special Requirements of Resistance Tests

Although some resistant strains are virtually immune to the highest doses of insecticide which can be applied, generally speaking, resistance is a matter of degree; in other words, it involves comparison with a normal susceptibility level. The most convincing proof of a resistant strain can be gained by rearing it, together with a normal colony under the same conditions, and testing the two side by side. Unfortunately, it is not always possible to do this; for one thing, results may be required quickly in the field. In such circumstances, the best method is to employ a standard test under various field conditions on the normal insects before a spraying campaign, or in an untreated area. If this is not possible, these preliminary tests should be done as early as possible, before resistance is suspected. From the results of such preliminary surveys, base lines of susceptibility will be obtained for various conditions (e.g., summer plus high temperature, or winter plus low temperature, etc.). These will give the normal variations of susceptibility to be expected in the particular insect species under consideration. Resistance will be evident in a marked and sustained departure from results obtained under equivalent conditions.

The actual test does not have to simulate field conditions, because it is intended to detect a change in the mosquito and is not concerned with the relative potency of the insecticide. Artificial exposure conditions are generally necessary to ensure precision and repeatability. (That is why, in the WHO resistance test, mosquitoes are exposed to insecticides in oil residues on filter paper rather than residues of wettable powders on dried mud or plaster.)

A satisfactory test for resistance should not merely detect it but should be able to measure it. For this purpose, batches of insects are exposed to a series of concentrations of insecticide to determine the dosage-mortality regression line. The results (of normal insect populations) may be plotted as straight lines by converting percentage kills to

probits and the concentrations to their logarithms; or, more simply, by entering them directly on logarithmic/probability paper.

Interpretation of Dosage Mortality Data

A straight dose/kill regression line represents a normal curve of distribution. The point at which the line cuts the 50 per cent. (5 probit) level represents the median point (the peak) of the curve. The slope of the line indicates the amount of spread of variation in the population, a flatter line indicating wider spread. It should also be noted, however, that a flat slope can be due to large errors of measurement or additional uncontrolled factors which contribute to variability. This can easily be shown from the fact that measurements of resistance by two different methods may give dosage-mortality curves of different steepness the same population. The two methods may also indicate quite different levels of resistance of a given colony. Generally, one would expect the method with flat dose/kill curves to give a somewhat exaggerated figure for resistance (BUSVINE, 1956). In any case, it is clear that results obtained by different techniques (e.g., for adult and for larval mosquitoes) are not directly comparable.

A given concentration/mortality regression line should be characteristic of a particular species and insecticide under specified conditions. Should the environment change or the physiological state of the insect (e.g., different temperature or state of nutrition), the position of the regression line may alter.

A typical change is shown in Figure 1 where lines A and B represent a normal strain of insects tested under different conditions. Line D represents a pure homogeneous colony of a resistant strain; but, naturally, this is not likely to appear suddenly in the field. What happens is that the nucleus of resistant individuals, being favoured by selective mortality of susceptibles, gradually increases and can be detected as soon as it forms an appreciable proportion of the population. In Figure 1, curve C indicates the form of concentration-mortality graph to be expected with a mixed population containing 80 per cent. susceptible (like 'B') and 20 per cent. resistant (like 'D'). The plateau of the curve will gradually get lower as the proportion of resistant individuals rises.

It is now clear that the detection of incipient resistance is easier at the high concentration levels. The WHO test instructions recommend routine tests at the lowest mortality which gave complete kills with the normal strain. Repeated survivals, *under the conditions of the original test*, strongly indicate incipient resistance. This should be confirmed by tests over the whole concentration range to determine whether a curve of type 'C' is found. If so, it will indicate the proportion of resistant individuals in the population.

Some Standard WHO Tests

Test for Adult Mosquitoes. In 1954, the Malaria Committee of the WHO adopted a method described by BUSVINE and NASH (1953); but this was later modified to incorporate certain features suggested by Dr. R. W. FAY and others (WHO, 1957). The new technique, which has been thoroughly tested in the laboratory (FAY, 1957; BUSVINE, 1959a) and in the field, supersedes the Busvine/Nash test; but the two methods give equivalent results (DE ZULUETA 1959; UNGUREANU and CRISMARU, 1959).

In principle, mosquitoes are confined in small tubes lined with filter papers impregnated with different concentrations of insecticide (DDT or dieldrin) dissolved in a non-volatile oil. After a standard exposure (usually one hour) they are removed to a clean environment and held for 24 hours before mortality counts. It will be noted that the insects are made to dose themselves by walking over treated surfaces. Methods in which they are dosed individually by application of small drops of insecticide solution have been tried (LIVADAS and THYMAKIS, 1956; UNGUREANU, 1959). Theoretically more precise, this technique is not feasible for general field use; moreover, the users found that Busvine/Nash tests gave similar indications of relative resistance.

Nevertheless, it is certain that some factors affect the dosage of mosquitoes on treated surfaces; for example, anything tending to make them move about more. This is almost certainly the reason for the low kills obtained when only single mosquitoes are used in each tube, instead of several (RAFFAELE and COLUZZI, 1957). There are also the lower kills obtained in darkness than in light (BUSVINE, 1959), and again, the lower kills obtained at lower temperatures (DUPORT *et al.*, 1958; BRANSBY-WILLIAMS, 1959), which are at least partly due to decreased movement. The big differences in susceptibility of northern species of anophelines in summer and autumn had been associated with fat body changes prior to hibernation (DE ZULUETA *et al.*, 1957). But, if such experiments are done at different times of the year but at the same temperature, the fall in susceptibility in autumn is much less (GARMS *et al.*, 1959; though the authors do not point this out).

The effects of temperature may alter with different insecticides. Thus, UNGUREANU *et al.* (1959) have shown that there is a bigger effect with dieldrin and BHC than with DDT. It appears that with all three insecticides the pick-up is greater at high temperatures and the susceptibility to dieldrin and BHC likewise increases. But with DDT, susceptibility decreases (*see* BUSVINE, 1957, p. 35) and this partly nullifies the greater dose acquired.

The Busvine/Nash test and the WHO method for adult mosquitoes, which has superseded it, have been used to define normal susceptibility levels for a very considerable number of mosquitoes (GARRETT-JONES, 1959). In general, these tests have worked well, giving steep dose/kill regression lines. A point which has caused some confusion is the difficulty of obtaining complete concentration/kill curves with resistant strains, since the saturation concentrations may give only a low mortality (e.g., curve D in Figure 1). In such cases it is useless to try to raise the saturation level by additional solvent; the proper course is to use increased exposure time. In one case it was found that the LC_{50} was related to exposure so that concentration $\times$ time was roughly constant (BUSVINE, 1959a). While this

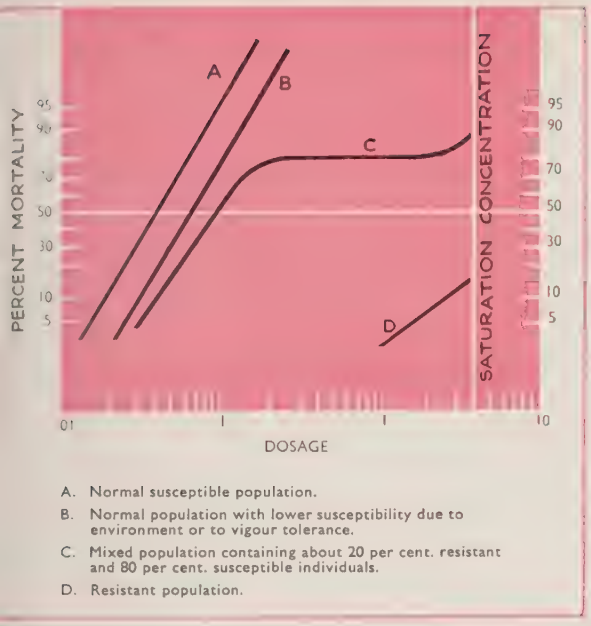


FIG. 1. *Hypothetical dosage/mortality curves to illustrate different aspects of resistance.*

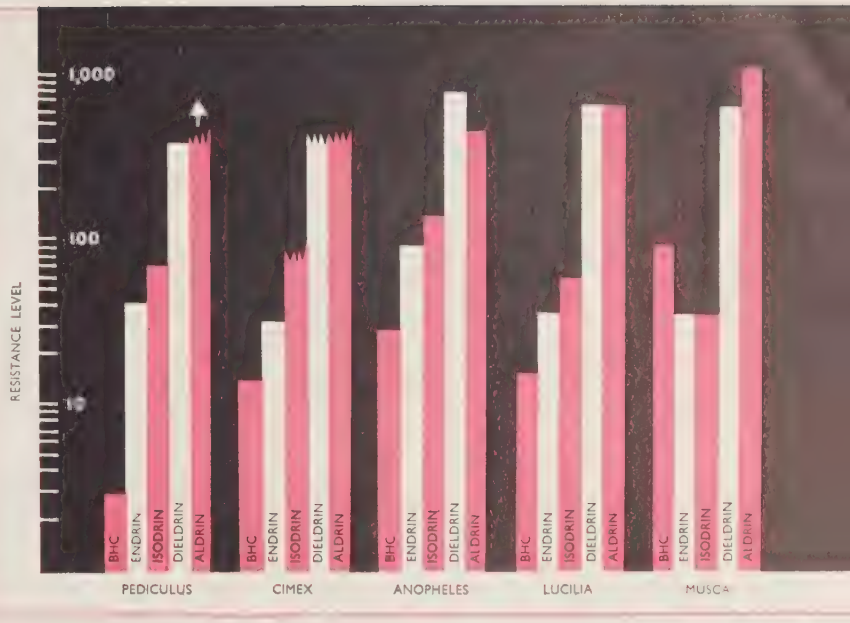


FIG. 2. *Resistance spectra obtained by measurements of relative resistance to the BHC-dieldrin group of insecticides. (Data from various sources.)*

may be a helpful guide it would be unwise to rely on it for estimating resistance which should always be done by comparing LC_{50} values at the same exposure time.

Other Impregnated Paper Tests

Since the introduction of the standard WHO test kit for adult mosquitoes, impregnated papers have been prepared on a large scale and distributed to many countries. It would seem sensible to utilise them for detecting and measuring resistance in other insects besides adult mosquitoes.

Houseflies. Attempts to utilise the mosquito technique for tests on houseflies have not been successful. With the chlorinated synthetic insecticides the levels of resistance have been so high that the test has been useless for quantitative work. As far as organo-phosphorus insecticides are concerned, technical difficulties prevent direct adaptation of the existing technique (for example, they will not dissolve in Risella oil).

In contrast to the failures of impregnated papers for tests on houseflies, very encouraging results have been obtained with other insects such as sandflies, tsetse flies, blackflies and cone-nose bugs. An even simpler test, employing only the impregnated papers cut into small pieces and put into test tubes, has been proposed as a provisional method for bed bugs and fleas.

Bed Bugs. The method for adult bed bugs was described by BUSVINE (1958) who showed that susceptibility of normal bugs to DDT was very low immediately after feeding but that it reached a convenient level about five days after feeding before mortality from starvation was important. Effects of temperature were investigated, over the range 20° to 30°C., by BUSVINE and LIEN (1960) who found little effect on the LC_{50} with DDT; but susceptibility to dieldrin was increased with a rise in temperature. This is consistent with the results of UNGUREANU *et al.* (1959) already mentioned.

The results available with the bed bug test suggest that the following simple test could be used to detect resistance. All normal bugs (*Cimex lectularius*) kept on papers impregnated with 4 per cent. DDT or 0.4 per cent. dieldrin, for five days at 25°C., should be killed. For the tropical bed bug (*C. hemipterus*), which is more susceptible, 2 per cent. DDT and 0.2 per cent. dieldrin could be used. Survivors in any such tests are very likely to be resistant.

Fleas. A method very similar to that used for bed bugs is being tried for detecting resistance in fleas (especially *Xenopsylla cheopis*). The fleas are made to crawl on small folded pieces of impregnated paper in test tubes, in the same way as the bugs. However, a much shorter exposure time (one hour, or perhaps 24 hours) is required.

Mosquito larvae

At a meeting of the WHO Expert Committee on Insecticides in 1956, a provisional method for measuring susceptibility or resistance in mosquito larvae was drawn up; and at a subsequent meeting in 1957 this was adopted.

The method has been tried in various laboratories and, to some extent, in the field; but it has been much less widely employed than the adult test. Certain points have emerged from these trials. The exposure period is rather long for certain delicate larvae, which suffer some mortality from starvation after 24 hours. This fact, together with the inconvenience of 24-hour experiments in some field work, has led certain workers to try shorter exposures. Thus, ELLIOTT (1958) employs a one-hour exposure,

followed by five hours' holding period, before mortality counts. However, the short exposure involves other difficulties in that the concentrations necessary are unduly high and probably involve changes in physical nature at the upper levels. At a recent meeting of the WHO Expert Committee on Insecticides, it was decided to retain the standard method, while recognising that Elliott's modification might be useful in special cases.

Test for Blackfly Larvae

Another method for aquatic insects is a proposed test for resistance in blackfly larvae. This has been described by MUIRHEAD-THOMSON (1957) and has been used successfully by one or two other workers, but only with the species *Simulium damnosum*. It will not be adopted as a standard WHO test until there is further evidence of its suitability for other kinds of blackfly larvae.

Tests for Human Lice

Between 1953 and 1956, the WHO issued 530 test kits for detecting resistance in body lice. The test is described and the results of workers in various countries are assembled in a paper by WRIGHT and BROWN (1957). In this test, lice are exposed to small pieces of cloth dusted with different concentrations of insecticides in powder form.

In general, the test has been found convenient for indicating the presence of resistance and giving a rough idea of the degree; but it is not a precise test owing to the very flat curves relating dosage and mortality, which seems to be a characteristic of the method. The data obtained were not adequate to assess LC_{50}s. Further concentrations of insecticide have been added to later versions of the test kit in the hope that this may be possible.

An alternative method of detecting and measuring resistance in lice, with the aid of insecticide-impregnated papers, has been used by SMITH (1959) and BUSVINE and LIEN (1959). This test is more precise and reliable, but it is not proposed to use it to replace the old method at present.

Resistance Tests in Basic Studies

The WHO tests for resistance have been designed primarily for field use, because this was where there was the most urgent need for reliable standard tests. In some cases, however, the tests have been found sufficiently precise to be used in basic studies on resistance in the laboratory. There are two types of investigation which have utilised these tests: (a) genetical studies; (b) toxicological investigations involving 'resistance spectra' (patterns of relative resistance to groups of analogous poisons).

Genetical Experiments. DAVIDSON (1958) used the Busvine/Nash test in his pioneer elucidation of the mode of inheritance of dieldrin-resistance in *Anopheles gambiae* and DDT-resistance in *A. sundaicus*. COKER (1958) and QUTUBUDDIN (1958) used the WHO test for larval mosquitoes in their studies of the inheritance of DDT-resistance in *Aedes aegypti*.

Resistance Spectra. BUSVINE and COKER (1958) worked out the resistance spectra of three DDT-resistant strains of *Aedes aegypti*. BUSVINE (1958) obtained resistance spectra for BHC/dieldrin-resistant bed bugs and has recently derived a very similar pattern for the same type of resistance in human body lice. DAVIDSON (1958) also got this type of pattern with Busvine/Nash tests on *A. gambiae* (Figure 2).

Lord Kelvin once said something to this effect: 'If we can measure a thing and if we can express it in numerical terms, we begin to know something about it. But if we cannot measure it nor speak of it in numerical terms, our knowledge is of a vague and unsatisfactory kind'. This dictum is more or less applicable to most branches of science and it is certainly very relevant to the biological phenemonon of insecticide resistance. Test methods for the detection and measurement of resistance should provide, in the first place, reliable information of the extent and degree of resistance and hence of the seriousness of each problem. Secondly, the shape of the dosage/mortality curve should indicate the proportions of resistant individuals in the population and reflect any changes in these proportions in the course of time. This in turn is closely linked with the genetics of resistance. Finally, measurements of relative resistance provide 'resistance spectra' which characterise different forms of resistance leading on to basic research on the subject.

Clearly, no valid conclusions can be reached in any of these fields unless the actual measurements are reliable.

REFERENCES

BRANSBY-WILLIAMS, W. R. *Bull. Wld. Hlth. Org.* **20,** 149, 1959.

BUSVINE, J. R. *Chem. and Ind.* p. 1190, 1956.

BUSVINE, J. R. 'Techniques for Testing Insecticides'. Commonwealth Bur. Ent. London. 30$, 1957.

BUSVINE, J. R. *Bull. Wld. Hlth. Org.* **19,** 1041. 1958.

BUSVINE, J. R. *Indian J. Malariol.* **12,** 279, 1959a.

BUSVINE, J. R. and COKER, W. Z. *Bull. Wld. Hlth, Org.* **18,** 651, 1958.

BUSVINE, J. R. and LIEN, J. *Bull. Wld. Hlth. Org.* (in press), 1960.

BUSVINE, J. R. and NASH, R. *Bull. ent. Res.* **44,** 371, 1953.

COKER, W. Z. *Ann. trop. Med. Parasit.* **52,** 443, 1958.

DAVIDSON, G. *Bull. Wld. Hlth. Org.* **18,** 579, 1958.

DUPORT, M. *et al. Bull. Wld. Hlth. Org.* **19,** 1112, 1958.

ELLIOTT, R. *Trans. R. Soc. trop. Med. Hyg.* **52,** 527, 1958.

FAY, R. W. *WHO Insecticide Committee Working Paper No. 18,* 1957.

GARMS, R. *et al. Z. Tropenmed. u. Parasit.* **10,** 48, 1959.

GARRETT-JONES, C. WHO/Mal./242, 1959.

LIVADAS, G. A. and THYMAKIS, K. *Bull. Wld. Hlth. Org.* **15,** 403, 1956.

MUIRHEAD-THOMSON, R. C. *Amer. J. trop. Med. Hyg.* **6,** 920, 1957.

QUTUBUDDIN, M. *Bull. Wld. Hlth. Org.* **19,** 1109, 1958.

RAFFAELE, G. and COLUZZI, M. *Riv. Malariol.* **36,** 157, 1957.

SHEPARD, H. H. (ed.) '*Methods of Testing Chemicals on Insects*'. Vol. 1, Burgess Co., Minn. £2 2s., 1958.

SMITH, A. *Bull. Wld. Hlth. Org.* **21,** 240, 1959.

UNGUREANU, E. *Bull. Wld. Hlth. Org.* **20,** 990, 1959.

UNGUREANU, E. and CRISMARU, V. *WHO Insecticide Committee Working Paper* No. 2, Add. 5. 1959.

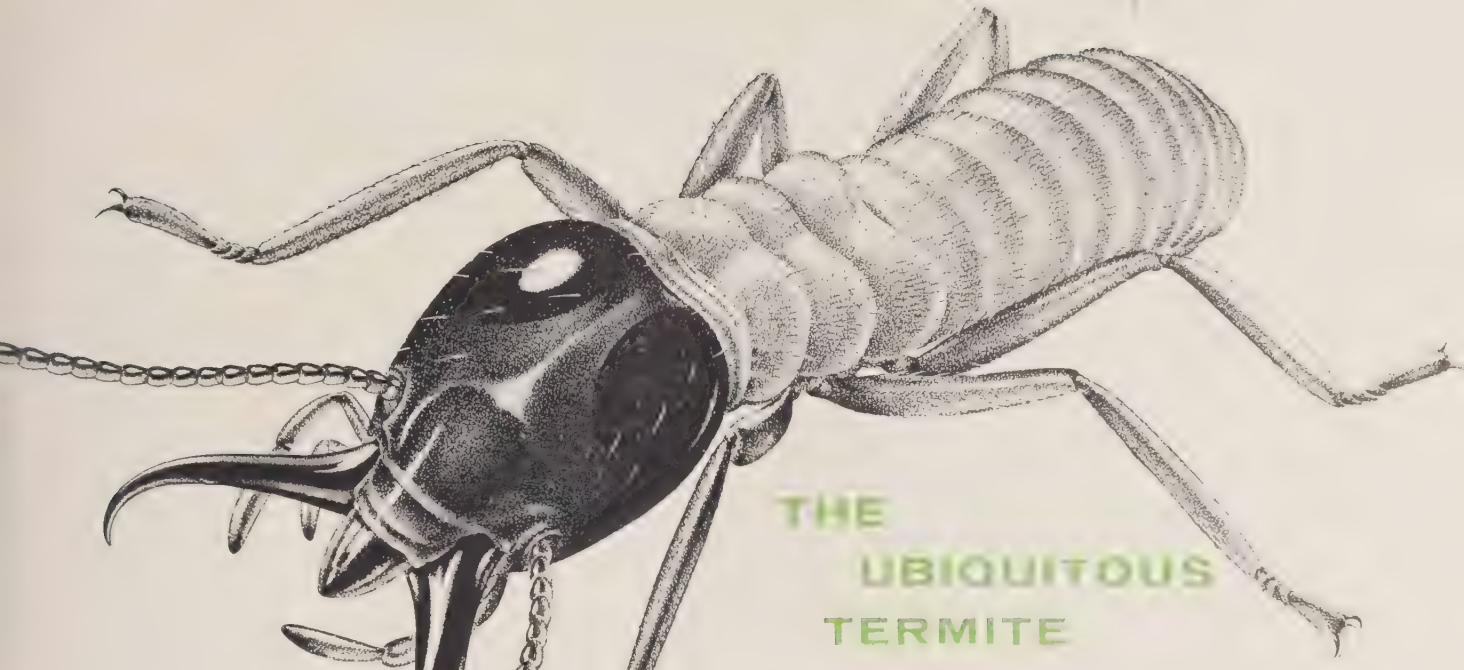
UNGUREANU, E. *et al. WHO Insecticide Committee Working Paper* No. 2, Add. 6, 1959.

WORLD HEALTH ORGANIZATION. 7th Rpt. Expert Committee on Insecticides, *Tech. Rpt. Series* No. 125, 1957.

WRIGHT, J. W. and BROWN, A. W. *Bull. Wld. Hlth. Org.* **16,** 9, 1957.

ZULUETA, J. DE, *et al. Bull. Wld. Hlth. Org.* **16,** 475, 1957.

ZULUETA, J. DE. *Bull. Wld. Hlth. Org.* **20,** 797. 1959.



THE UBIQUITOUS TERMITE

by **W. Victor Harris,** *Officer in Charge, Colonial Termite Research Unit, London.*

Termites are found in almost every part of the world.

Termites are insects with a partiality for wood in all its many forms, natural and manufactured. Some termites feed only on dry seasoned timber such as is found in furniture and the structure of houses, others prefer damp timber in contact with the soil or in boats. The woody tissues of growing plants provide food for many different termites, while others that inhabit forest soils live on humus, which is cellulose partly decomposed. Paper, cloth and cellulose acetate plastics are among the manufactured products which termites eat. Finally, there are materials such as synthetic rubbers, plastics not derived from cellulose, and even soft metals like lead which, while not in the least nutritious, are liable to be damaged by termites seeking food, or perhaps chewed 'for fun' as humans chew gum.

Throughout the world between latitude 42 degrees north and latitude 42 degrees south of the Equator termites are usually to be found. Their distribution is governed in part by the presence of suitable food, and in part by temperature. Termites are kept out of the cooler parts of the world by winter temperatures too low to maintain life, but an even greater factor appears to be a summer temperature too low for adequate reproduction. In the tropics they are active up to about 7,000ft. above sea level, after which they diminish in numbers, and voracity. In Europe they are found along the Mediterranean and Black Sea coasts and as far north as La Rochelle on the French Atlantic coast, where the Gulf Stream augments the summer heat. A North American termite is established in some old buildings in Hamburg, where it aggravates

the existing nuisance of woodworm, house longicorn and the like, but it is not yet known to be spreading.

The cost of termite damage is difficult to assess, especially in agriculture and forestry. As a result of termite damage to cane setts in one Indian province alone the value of the sugar lost has been estimated at around £1,400,000 a year, but so many factors need to be taken into account that estimates of crop losses are at best approximations. With buildings the position is more clear. For instance, the 1943 Census in Jamaica showed that 60 per cent. of the houses on the island were infested with termites. The estimated cost of repairing termite damage to Government buildings in Nigeria, Ghana and Sierra Leone was estimated in 1955 as of the order of £250,000 a year. On the island of Bermuda, a few years ago, £5,000 was spent in eradicating termites from the roof of the Cathedral at Hamilton.

Among the earliest of winged insects to appear—the termites belong to the Order Isoptera and are related to the cockroaches—they developed various levels of social organisation which have stood them in good stead under differing living conditions, and today there are no termites which do not live in communities. In other words, it is the termite community which has to be reckoned with, and not a series of individual insects, whether the community is numbered in dozens as in the dry-wood termites, or in millions as in the giant mound builders of the African savannahs.

The destructive activities of termites would be appreciated far more if they fluctuated in numbers seasonally or over a period of years, as do locusts, cutworms and, in a related context, hurricanes. Instead, they are present all the time, just out of sight, and waiting—waiting for cracks in the foundations of a building that will allow them to climb in and eat the furniture or the door-frames, or waiting for a period of drought which will cause maize and tobacco plants to wilt and become palatable. Careless pruning of trees leaves stumps of branches that cannot be calloused over before termites have located the unprotected wood. Perhaps it is a latent suggestion of past carelessness that influences many people in their disregard for the inevitability of termite attack.

Types of Damage

The greatest amount of material damage caused by termites is undoubtedly that done to buildings, and to their contents. This has increased greatly over the past 15 years; firstly, because of the rapid expansion of building in many tropical countries; secondly, because of the increased use of non-resistant timbers, fibre boards and the like; and thirdly, because of the reckless adoption of new building designs conceived by architects ignorant or neglectful of termite attack. That such attack is not at all a novelty may be seen from the writings of the Conquistadores who conquered Central America in the sixteenth century.

Damage to growing crops is on a comparatively small scale, at least in relation to the extent of the opportunities that there would appear to be. In fact it is widely held that termites are never true primary pests and that any damage which they appear to do to plants is secondary, with the real cause to be sought elsewhere. Correct diagnosis of pests and diseases on plants is not easy, while preconceived ideas and prejudices cloud the issue. Among annual crops we find termites attacking jute in West Bengal, wheat in India (with loss of yield estimated at up to 25 per cent) and Tanganyika, groundnuts in West Africa and the Sudan, tobacco in Uganda and Rhodesia, cotton in East Africa and the Sudan, and Irish potatoes in Jamaica. Sugar cane setts are damaged before the young plants are well established in India, Queensland and the Caribbean. Domestic animals have to share their grazing with harvester termites in many low rainfall areas, but only in those countries where grazing is a part of settled farming practice —as in Africa south of the Limpopo River—does this cause any concern.

With plantation crops such as tea, cocoa and rubber, and with forest trees, termite damage is greatest when the plants are either young or elderly. Nursery plants are liable to attack when watered irregularly, or when weakened by excessive root competition. On planting out in the field young trees are vulnerable until they have recovered from shock and grown enough to callous over all wounds—usually one year at least. Re-afforestation programmes in semi-arid areas are liable to serious disruption by termite attack, particularly during the dry season next following after planting. Over wide areas of the tropics and sub-tropics, successful afforestation with eucalyptus and other exotics depends on some measure of protection against termites during the first two years of the plantation.

Most of the injurious termites belong to one of the following groups:

(1) Dry-wood termites—those which live and work inside galleries in dry timber and dead branches still on the tree;
(2) Moist-wood termites—those which have nests in old tree roots or wood kept moist by contact with the soil, and whose workers travel far in search of food; and
(3) Ground-dwelling termites—an assorted group with well organised nests, some deep in the ground, some within large mounds of earth, and others attached to the trunks of trees; builders of covered run-ways to and over the food supply.

Preventing Termite Damage to Buildings

Buildings can be designed and constructed to prevent ground-dwelling and moist-wood termites gaining entrance from the ground below. 'Ant-proof courses' of reinforced concrete on foundation walls, metal 'termite shields' capping wood or masonry pillars, and concrete floors with expansion joints filled with termite-proof jointing compound, these are some of the methods employed to frustrate termites. However, accidents do happen, due to careless builders, settling of foundations or earth tremors, and sooner or later gaps may appear through which the termites will have access to the superstructure. For this reason it is a wise and simple precaution to poison the soil

Termites have caused these bare patches in a swamp grazing in Kenya.

around the foundations and under any slab floors while the building is under construction. Soil poisoning is never so easy to carry out once the buliding is completed. Protection lasts for a number of years, but it is by no means permanent and cannot be regarded as a substitute for good design.

Dieldrin emulsions are suitable for site poisoning, and for remedial treatments. The concentrate is diluted with water to give a 0.5 per cent emulsion (i.e. 1gal. 15 per cent dieldrin concentrate would be mixed with 29gal. water) and this is sprayed or sprinkled over the inner surfaces of the trenches when the foundations have reached ground level. One gallon of emulsion is used for each yard of trench, either in one application, or in two or three as the soil is being filled back. Interior walls must not be left untreated, and any subsequent pipe-laying or similar activity will need to be followed by spraying of the disturbed area in order to preserve intact the protective zone of poisoned soil. Where slab floors are to be used, the completed fill should be sprayed with this solution at the rate of 1gal. per 12sq. ft., preferably using a template or some other guide to obtain a regular and even distribution.

In some parts of the tropics, notably on islands and the coasts of the continents, dry-wood termites are active in the woodwork of buildings. Since these termites have no connection whatever with the ground, they are not kept out by constructional means effective for subterranean termites. The only sure way of avoiding this damage is to use for constructional purposes only those timbers which have some natural resistance to attack—such as teak, iroko and mahogany—or timbers which have been impregnated with an effective preservative. Wood preservation is too complicated a subject to be dealt with here; like most things it is a waste of money if not done properly.

A point about dry-wood termites which merits emphasis is that detailed observations suggest that the risk of infestation of new buildings comes not so much from pairs of flying termites at swarming time, as from the introduction of colonies in timber used for construction, or in furniture and fittings removed from infested buildings. Wood preservatives containing dieldrin and formulated for quick penetration are suitable for treating infested furniture and so preventing the spread of dry-wood termites. Another way is fumigation with methyl bromide, though this will not guard against future attack.

Preventing Damage to Crops and Trees

It is, perhaps, with growing crops that termite prevention has progressed most rapidly as a result of the development of chlorinated hydrocarbon insecticides for soil treatment. The relative impermanence of these compounds as compared with those containing arsenic, lead and other metals is, in itself, an advantage since protection is usually needed for one year, or at the most two. With annual crops and for sugar cane, dusts or emulsions may be used at planting time. The order of dosage is from 2lb. to 2½lb. of aldrin or ½lb. to ½lb. dieldrin (active material) per acre, applied as a broadcast treatment in the most convenient manner with regard to the equipment available.

For the protection of trees these insecticides may be used both in the nursery beds, and later in the planting

West African dry-wood termites, Cryptotermes havilandi, *have played havoc with this sheet of ply-wood from Nigeria.*

holes where they will ward off termites until the transplants are established. The destruction of rootlets during transplanting, and such practices as stump planting encourage termite attack by exposing unprotected tissues. Alterations in technique, for example planting out young trees in containers which will disintegrate in good time, are worth consideration in areas where termite attack is prevalent. Methods to be adopted in order to ensure that the insecticide will be thoroughly incorporated with the soil surrounding the plant depend on local circumstances. The barrier produced must be complete to be effective. Potting soil requires a one per cent dieldrin dust incorporated at a rate of 10oz. per cubic yard; this is most easily done if a rotating mixing drum is available. Otherwise the pots, when set up, may be watered with a diluted dieldrin emulsion to give a comparable dosage. In Malaya young rubber trees are protected for two years with from one to two pints per tree of dieldrin emulsion (one part Dieldrex[1] 15 to 300 parts water) or aldrin emulsion (one part Aldrex[1] 2 to 400 parts water).

Destruction of Termite Colonies

Termite mounds are a feature of large parts of the countryside in tropical Africa, southern Asia, and the more northerly states of Australia. Large mounds are serious obstacles to mechanised agriculture. Small mounds may be a menace to aeroplanes using grass run-ways. In some cases, but not invariably, the termites which inhabit such mounds are detrimental to crops and grazing, and to buildings in the vicinity. Simply to knock down a mound does not mean that the termites will not rebuild. To be sure, the inhabitants of a mound must be killed and then there is no risk of rebuilding.

Working on this problem in Northern Nigeria, W. A. Sands, of the Termite Research Unit, has found that the compact nests of *Macrotermes* within large mounds react very well to aldrin. Holes are made through the hard walls of the mound into the central 'hive' by means of a 1½in. screw auger welded to a steel rod 4ft. long. Three holes are enough for the usual mound 7ft. or 8ft. high, and down each of these is poured 2gal. diluted aldrin emulsion. The 6gal. required for each mound contains 2½fl. oz. aldrin 40 per cent emulsifiable concentrate. A short length of plastic hose is used to introduce the fluid beyond the outer layer of the mound where it would be absorbed without affecting the colony.

Small mounds of the kind which appear like boulders on pastures and air-strips, and the subterranean nests of *Odontotermes* which produce funnel-like openings on roads and paths, or in irrigation works—these can be treated with D-D[2] Soil Fumigant. While more than ordinary care must be taken with this fluid, it is rapid in action and penetrates quickly into all parts of the nest. Precautions are necessary to avoid dissipating D-D in the upper layers of the soil as the volume of liquid used is small.

[1]Aldrex and Dieldrex are Shell trade marks.

[2]D-D is a Shell trade mark.

INTERNATIONAL PLAN FOR DESERT LOCUST CONTROL

In recent years crop damage by swarms of the desert locust has been greatly reduced by the defensive measures undertaken by affected countries. But, although these measures have been successful in protecting crops, they have made little or no contribution to the long-term solution of the desert locust problem, for swarms continue to emerge much as they have always done and their potential danger is as real today as it was one thousand years ago.

A combination of factors underlies the reason for this state of affairs. Technically, not enough is yet known about the ecology of the desert locust in its principal breeding areas, and for this reason, and because such areas are often extremely remote, it has not so far been possible to conduct large-scale campaigns at the most advantageous time and place. The international nature of the problem also introduces political difficulties which have to be overcome before such large-scale campaigns can be carried out.

Recently, a panel of locust experts, in conjunction with FAO, have restated their view that no solution to the problem will be forthcoming without a greater degree of international cooperation, and a change from a defensive to an offensive strategy. This view is now generally accepted and plans are now being made to put the panel's recommendations into effect.

The first steps to be taken in these plans include the expansion of ecological surveys in the main swarm producing areas; the intensification of research on the desert locust, particularly in the field, and on methods of control; the strengthening of locust reporting, information, and forecasting services; the provision of increased training facilities for nationals of all countries affected by the desert locust; and, finally, the testing and demonstration of locust control operations by the most modern techniques.

This programme will be put into effect under an interregional research project which has been drawn up by FAO, and will be carried out over a period of six years. The cost of this project is expected to amount to $3,759,050, two-thirds of which will be borne by the United Nations Special Fund, and one-third by the 18 countries which have agreed to participate. It is expected that during the six-year period of the project sufficient experience will have been acquired to enable the participating countries to adopt the most appropriate means of keeping the locusts within bounds, and thus substantially reduce the heavy annual cost of control operations at present incurred.

Residual Effects of Insecticides on Fruit and Vegetables

by **Simone Dormal,** Dr. ès Sc.
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Among modern methods of agricultural pest and disease control the use of pesticides has now taken the lead from such methods as biological control, the development of varieties of resistant plants, the reduction in size of adjacent plots, and sowing at special times in order to break the life cycle of the insect; for pesticides have proved, in many cases, to be more effective and more practical on a large scale.

The capital invested today in the control of plant pests is considerable, the range of pesticides is extended daily and there are more than 1,200 products for agricultural use on the Belgian market alone, based on nearly 200 different active materials. The length of the list of pesticides now in use tends to arouse fears in the consumer about the safety of treated crops, but systematic investigations carried out over the last few years in the spheres of microanalysis and toxicology, as applied to the study of pesticide residues, enables us to form a fairly clear view of the situation, at least as far as the most commonly used products are concerned.

The complex phenomena involved mean that each treatment must be regarded as an individual case, and in view of the many variable factors entailed, transposition of results is only permissible where working conditions are identical.

Changes in Pesticide Deposits

After partial loss through run-off the application of pest control treatments to plants may give rise to the formation of initial deposits which immediately begin to alter. Inorganic and polar or ionic organic compounds are not usually fat-soluble and cannot penetrate the plant cuticle and they only undergo external decomposition. The non-ionic organic compounds also undergo external decomposition, but usually for a much shorter period, since, being soluble in the waxy cuticle of plants, they often penetrate it very rapidly and are then subject to another kind of breakdown process, i.e., metabolism within the plant by the action of the enzyme systems and the various biochemical processes of the substrate.

Surface Residues

Decrease in surface residues arises from a large number of indefinable factors covered in the literature by the term 'weathering', and including mechanical effects such as the

[1] Supported by l'Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture (I.R.S.I.A.).

erosive action of the wind, the friction of leaf surfaces against one another, and washing by rain; physical effects, such as going into solution under conditions of high humidity, dehydration, distillation, crystalisation, and sublimation under the action of heat; and chemical effects such as oxidation in sunlight and hydrolysis under conditions of high humidity. These effects combine to bring about the disappearance of the residues, by progressive physical and mechanical elimination on the one hand, and chemical change on the other.

Although the part played by the physical and chemical nature of the active material in the persistence of the surface residues is of paramount importance, the type of formulation, application, nature of the substrate and time of treatment all have a marked effect. Generally, emulsions have a greater residual effect than suspensions, which in turn are more persistent than powders. The incorporation of detergents into formulations for increasing covering capacity reduces the persistence of the residue in that the products are more easily washed off; the incorporation of stickers, on the other hand, increases it.

According to HORSFALL (9) small particles withstand weathering more successfully than larger particles. Confirmation of this hypothesis was possible during research on the resistance to precipitation of DDT residues, in the form of wettable powder, on runner bean and pear tree leaves (5).

As regards the nature of the plant epidermis, it has been noted that residues adhere better and in larger quantities on fruit and vegetables with a rough or hairy surface than on smooth surfaces treated under the same conditions.

Finally, it should be noted that the time of treatment plays an important part in the speed at which a residue disappears, because of the connection between the residue and the stage of development of the plant. When treatment was carried out on pear trees with arsenic formulations RAUCOURT *et al.* (16) showed that the apparent loss in arsenic due solely to the growth of the fruit, after a lapse of 35 days, represented 69 per cent. of the total loss of arsenic. The remaining percentage 'loss' was accounted for as follows: washing away by rain, 11 per cent.; other causes, 20 per cent. WEBSTER (20) who studied the same problem, assessed the daily losses in arsenic at 3.6 per cent. and 1.3 per cent. on pears at the beginning of the summer and autumn.

Penetration Residues

Non-ionic organic compounds are generally able to penetrate the plant epidermis, so that the effective time for external decomposition is considerably reduced.

The speed of penetration of the compound into the plant tissues depends essentially upon the chemical nature of the product, the type of formulation and the kind of plant epidermis. Generally, the residues of compounds in the form of emulsifiable concentrates penetrate with surprising rapidity into the cuticular and sub-cuticular tissues. Phosphoric esters in wettable powder form seem to penetrate equally rapidly. Powders, on the other hand, have a much lower power of penetration.

It has been observed during experimental treatment that the residues of parathion, chlorthion and isochlorthion left by emulsion treatment almost completely penetrate cherries in less than three hours after spraying (6). On peaches, DDT and parathion residues only penetrate into the pulp when the treatment has been carried out with emulsion (1, 2). Whatever the kind of formulation, no residue penetrates the pulp of citrus fruits with the exception of compounds with a systemic effect, which circulate throughout the plant (4).

Once incorporated into the plant tissues the penetration residues gradually disappear under the action of internal metabolic processes, losing their chemical identity, and becoming transformed into progressively more simple molecules which are finally excreted by the plant. The external factors, with the exception, perhaps, of temperature and certain types of radiation, in this case have little effect.

The changes of the residues within the plant are essentially a function of the chemical nature of the compound and the physiology of the substrate. Some products are oxidised, others hydrolysed, others dehydrochlorinated, and yet others undergo molecular rearrangements.

In a very interesting survey given at the Third International Symposium on Foreign Materials in Foodstuffs, GUNTHER (8) reviewed the products of metabolism from the main insecticides in various plant substrates. Table I is taken from his paper.

Table I—Degradation products of various pesticides

Pesticide	*Substrate*	*Established Degradation Products*
Aldrin	Carrots	Dieldrin
DDT	Citrus leaves Restaurant meals	Benzophenone derivatives, DDT ethylene
Demeton	Many	Many
Dithiosystox	Citrus, cotton	Oxidation products
Ethylene dibromide	Wheat	Ethylene glycol
Ethylene oxide	Many	Ethylene glycol
Methyl bromide	Cereals, grains	Fixed on $—NH_2$, —SH
Mitox	Several	Mitox sulphone
Nicotine	Greens	Cotinine
Parathion	Forage to milk	Oxidation products
Phosdrin	Vegetables	Hydrolysis products
R.6199	Citrus, cotton	Hydrolysis products
TEPP	Many	Ethylphosphoric acids
Thimet	Several	Oxidation products
Trithion	Alfalfa, apples, citrus	Oxidation products

It is interesting to note that the majority of these products undergo the same metabolic changes in the animal organism (3).

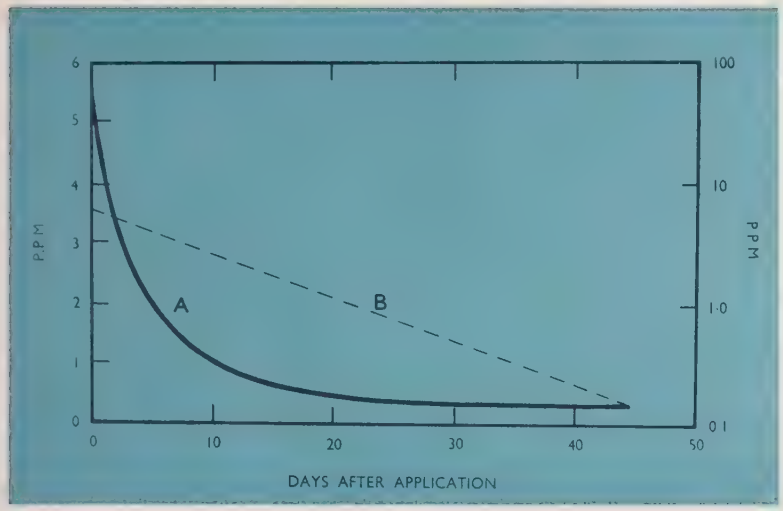


FIG. 1.

Plots of residue values against time with residues expressed as both arithmetic (**A**) *and logarithmic* (**B**) *functions.* (*From* Analysis of Insecticides and Acaricides, F. A. GUNTHER and R. C. BLINN, *Interscience Publishers, New York and London*, 1955.)

The study of these phenomena underlines the importance to be attached, on the one hand, to the identification of the products of metabolism of the residues in the plant substrate, and, on the other hand, to the method of analysis used for detecting the residue. This is indispensable for the interpretation of the results obtained.

Interpretation of Experimental Results

The curves for decomposition of the residues of inorganic and polar or ionic organic compounds seem to obey different laws according to the nature of the product. By detailed study of the decomposition of various kinds of fungicides, RICH (19) has interpreted this phenomenon as being due to varying intensities of attraction between the particles themselves and between the particles and the surface treated. There is, however, a proportional relationship between the loss of residues and certain simple factors such as rainfall. HORSFALL (9) and MILLER (11) showed in particular that the residues of Bordeaux mixture and copper oxide on the foliage of apple trees decrease as a function of the logarithm of the depth of rain.

Systematic analysis during the time between treatment and harvest, however, is at present the only rational method for studying the residues of these kinds of compound. The work carried out by RAUCOURT *et al.* (12-18) and HOSKINS (10) on arsenic residues on various kinds of fruit substantiate this fact.

The residues of non-ionic organic compounds lend themselves more easily to theoretical interpretation. GUNTHER *et al.* (7) were able to arrive at a fundamental law covering the behaviour of these kinds of compound. It appears that under fairly constant conditions of treatment, and for a single plant substrate, the actual amount of unchanged pesticide present at a given time depends upon the effective initial deposit. The percentage of the original deposit remaining at a given time after application is the same regardless of the magnitude of the initial deposit.

This relation is characteristic and shows that the surface and penetration residues of the non-ionic organic compounds disappear from the plant according to exponential type curves, if the amount of residue is plotted on linear coordinates against the days that have elapsed since treatment ['A' on Figure 1], and according to straight lines ['B' on Figure 1] if it is plotted as logarithmic function against days elapsed since treatment.

The exposition of this fundamental law makes it possible to assess the following, on the basis of results of analyses carried out at various times after treatment.

(1) The amount of residue for a certain compound, formulation and substrate at any time after treatment;
(2) The part played respectively by the formulation and the substrate in the residual effect of a compound;
(3) The period to be observed between the treatment and the harvest in order to ensure the safety of the consumer.

Practical Application

Determination of the residue life period of pesticides. The 50 per cent. residue life period (RL50=the time required for half of the residue to react or dissipate), being constant for a certain compound, formulation and plant substrate, the calculation of this value enables a rapid and comparative assessment of the persistence of the various products to be made. Table II summarises these figures for various insecticides on different plant substrates, the formulations used being either emulsions or wettable powders.

Establishment of the timing between the last treatment and harvest. Two problems arise in studying the limitations of residues in foodstuffs:

1. The establishment of the maximum admissible dosages (tolerances) based on the results of long-term toxicological experiments on the composition of the normal diet.
2. Fixing time intervals between the last treatment and harvest, in order to avoid the presence of residues at levels harmful to the health of the consumer.

In the United States and Canada, tolerances for residues

in agricultural commodities have been fixed by law, and time intervals between application and harvest have been established as a means of ensuring that such tolerances are not exceeded.

In Germany, Austria, Belgium, France, Great Britain, Holland, Switzerland and the USSR, although up to the present no tolerances have been officially fixed, the intervals to be observed between the last treatment and harvest have been the subject either of regulations or of recommendations.

These intervals vary according to the conditions laid down by the specialists in toxicology and phytopharmacy respectively, but they require above all a sound knowledge of the value and duration of pesticide residues on crops destined for human and animal consumption.

In Belgium, the time intervals laid down by regulations for pesticides which are toxic or which have a cumulative effect, are based on the tolerance of the smallest residual dose compatible with the length of time for which the product is biologically effective. For pesticides of low toxicity, or which have no chronic toxicity, a minimum time interval of 4-8 days is nevertheless laid down in order to avoid the presence of excessive dosages of foreign materials in foodstuffs.

Many products which have a very high acute or chronic toxicity are also subject to restrictions on their use. Accordingly, if the law is strictly observed, the quantity of residues which may be ingested from locally grown fruits and vegetables is negligible.

A more difficult problem to solve is that of pesticide residues on foodstuffs in store—cereals, milk, meat—as well as imported foodstuffs—but this falls outside the scope of this article.

REFERENCES

(1) Barnes, M. M., Carman, C. E., Ewart, W. H. and Gunther, F. A., *Adv. Chem.*, Series **1**, 112-116, 1950.

(2) Carman, C. E., Ewart, W. H., Barnes, M. M. and Gunther, F. A., *id.*, **1**, 128-36, 1950.

(3) Dormal, S., *Arch. Belges Med. Soc. Hyg. Med. Trav. Med. Lég.*, **2**, 61-78, 1957.

(4) Dormal, S., *Compte-rendu 3è Symposium sur les Substances Etrangères dans les Aliments*, Como, 1957.

(5) Dormal S., *et* Caussin, R., *Compte-rendu 4è Congrès International de Lutte contre les Ennemis des Plantes*, Hamburg, 1957 (in the press).

(6) Dormal, S. et Martens, P. H., *Revue de l'Agriculture* (in the press).

(7) Gunther, F. A. and Blinn, R. C., *Analysis of Insecticides and Acaricides* Interscience Publ. Inc., New York, 1955.

(8) Gunther, F. A., *Compte-rendu 3è symposium sur les Substances Etrangères dans les Aliments*, Como, 1957.

(9) Horsfall, J. G., *Fungicides and their action*, Chronica Botanica, Waltham, Mass., 1955.

(10) Hoskins, W. M., *J. econ. Ent.*, **42**, 6, 966-73, 1949.

(11) Miller, H. J., *Phytopathology*, **33**, 899-909, 1943.

(12) Raucourt, M., *Ann. Falsifications*, 293, May, 1933.

(13) Raucourt, M., *Ann. Epiphyties XII*, **5**, 145, 1946.

(14) Raucourt, M. et Sick, E., *id.*, **1**, 4, 1950.

(15) Raucourt, M., Trouvelot, B. et Cabane, E., *Rev. Path. Vég. et entomol. agr.*, **22**, 67-78, 1935.

(16) Raucourt, M., Trouvelot, B. et Castets, G., *Ann. Epiphyties et phytogénétique IV*, **2**, 337-56, 1938.

(17) Raucourt, M., Viel, G. et Chevrel, J., *Ann. Epiphyties*, **4**, 2, 227-56, 1953.

(18) Raucourt, M., Viel, G. et Ventura, E., *id.*, **7**, 3, 363-96, 1956.

(19) Rich, S., *Phytopathology*, **44**, 203-13, 1954.

(20) Webster, R. L., *J. econ. Ent.*, **27**, 2, 410-7, 1934.

Table II. **RL50 of various insecticides**

Insecticide	*Duration of RL50 expressed in days*						
	lettuce	tomatoes	spinach	runner beans	cherries	apples	peaches
DDT	2-3	—	12	9.5	18	—	8-18
Dieldrin	—	—	—	—	—	—	4-8
Parathion	1-3	3-7	2	1.5	2	3-6	3-7
Malathion	1-4	2-3	1	—	—	2-4	4-6
Isochlorthion	2.5	—	1-2.5	1.5-6	2	—	2-3
EPN	4-5	—	—	3	—	—	8-10
Phosdrin	—	0.5	1	0.5	—	—	—
Dipterex	3	—	1.5-3	1-5	—	—	2-2.5
Diazinon	1-1.5	—	—	2	1.5	4-7	—

SPECIFICATIONS

HOW THEY ARE USED

by **R. E. Gill,** B.Sc., Ph.D., *Shell International Chemical Company.*

In a previous article (*Span* **3**, 1, 27) reference was made to a number of general principles which could profitably be observed in drawing up specifications for formulated agricultural chemicals. These principles were briefly:

(1) That the specification should govern the performance of the product rather than its chemical composition;

(2) That the specification should contain clauses governing those physical and/or chemical properties of the formulation affecting the performance of the product which can also be measured quantitatively in the laboratory by a method capable of giving reasonably consistent results;

(3) That the specification must clearly define the precise method to be used to measure each of the properties referred to, and that these methods should, whenever possible, be simple methods not requiring the use of complex procedures or expensive apparatus;

(4) That the limits set in the specification in relation to each of the properties which are to be measured should be set realistically, i.e., in relation to the end use of the product and with due regard for the pre-determined repeatability of the test method;

(5) That the specification should not make reference to biological tests the performance of which in a routine basis would add considerably to the cost of the product.

The purpose of this second article is to illustrate the way in which these principles can be applied to specific types of formulations which are commonly used.

EMULSIFIABLE CONCENTRATES

It seems profitable to consider, first, the specification for an emulsifiable concentrate, typical of that which is used for general agricultural purposes. In its simplest form, an emulsifiable concentrate consists of a solvent in which the

biocide is dissolved, together with one or more emulsifiers, and additives which may have some special function. The emulsifiable concentrate can often be prepared simply by blending the ingredients together and by filtering the solution. It is, nevertheless, true that much has yet to be learned about the formulation of emulsifiable concentrates, and that a good proportion of the products of this type which are marketed give rise to a great number of complaints and practical difficulties.

The experienced formulator will be able to draw on the knowledge which he has acquired in relation to biological properties, such as phytotoxicity, when deciding upon the chemical composition of the emulsifiable concentrate which he is to manufacture. He will satisfy himself, and be prepared to give reasonable assurance to his customers, that the formulation which he has chosen to manufacture is suitable for the purposes which he will be prepared to recommend. Having regard to these purposes, he then has to decide on those physical and chemical characteristics which are to be included in his specification.

The properties of an emulsifiable concentrate which are of importance in practice and which can be measured directly or indirectly, include:

The percentage of biologically active ingredients;
The emulsion characteristics;
The low temperature stability;
The water content;
The flash point.

Active Ingredients

The specification will normally require that the product shall contain some stated minimum percentage of insecticide (or other biocide), as determined by some specific method of analysis which can be relied upon to settle any dispute, or by some relatively simple non-specific method which is suitable for routine purposes. Expressions such as 'minimum 20 per cent.' are, of course, insufficient. The concentration of the insecticide should be clearly expressed as 'minimum 20 per cent. w/w' or 'minimum 20 per cent. w/v' or 'minimum 20 per cent. v/v'. It is usually most convenient (especially when solid biocides are used) to use the 'per cent. w/v' basis, i.e., grams of biocide per 100 ml. of the liquid product (i.e., kg/100 litres or lb/10 I.G.). If this system of nomenclature is adhered to, variations in the specific gravity of the product become of no consequence. Furthermore, it is convenient for the user to know that a given *volume* of the product contains a certain *weight* of the biocide because dosage rates for field use are normally given in terms such as 'pounds of insecticide per acre', and it is easier to measure out a certain volume of the concentrate, rather than a certain weight of it. In order to allow for the fact that the volume of a liquid is affected by its temperature, the specification should refer to the temperature at which the concentration is to be measured.

Emulsion Characteristics

The most important physical property of an emulsifiable concentrate is, of course, its emulsion characteristics. It is well known that the properties of the emulsion formed when an emulsifiable concentrate is mixed with water depend on many factors, such as the identity and concentration of the biocide present, the physical characteristics of the solvent used, the rate of dilution with water, and the hardness and temperature of the water. Thus it is possible to formulate emulsifiable concentrates which, on dilution, will give rise to emulsions remaining stable for periods of minutes, hours or days. Nevertheless, although emulsions which break quickly may be preferred for certain purposes, whereas extremely stable emulsions may be preferred for other purposes, the conditions encountered in agricultural practice are generally met by employing emulsions covering a fairly narrow range of 'medium emulsion stability'.

Relatively simple laboratory tests can be used to obtain a quantitative estimate of emulsion stability in terms of the amounts of 'cream' or free oil which appear when the diluted emulsion is allowed to stand undisturbed for some hours. Such tests can give a fairly reliable indication of the way in which the emulsion is likely to perform under practical conditions.

As properties such as emulsion spontaneity and dilute emulsion stability are likely to deteriorate during storage, especially under high temperature conditions, it is advisable in the specification to require that the test for emulsion characteristics shall be repeated at the end of an accelerated storage test, which could, for example, involve storing a sample of the product in the laboratory for some weeks at an elevated temperature. In this way, the customer can be provided with a measurable indication of the storage life of the emulsifiable concentrate.

If there is good reason to suspect that the biocide itself is likely to break down during storage, it would also be desirable to include in the specification a clause limiting the decomposition of the biocide which may take place under the conditions of an accelerated storage test.

Low Temperature Stability

The specification should include a clause governing the low temperature stability of the product. Such a clause is important because it takes into account the fact that the active ingredient or some other material may separate or be precipitated during storage or shipment of the product in cold weather. The sediment so formed may subsequently cause blockage of spray nozzles, and it is in any case undesirable because it detracts from the physical appearance of the product.

The conditions of the cold temperature test can, of course, be varied in accordance with the conditions of storage, if these are known, and tests involving storage of a sample at 0°C for one hour, or at lower temperatures for much longer periods, have been employed. If the formulator is unaware of the ultimate conditions of storage, he will be wise to include in his specification a fairly rigorous test which may, for example, involve storage at 0°C for a week. The purchaser must recognise, however, that the preparation of formulations complying with such a test may well make it necessary to use expensive solvents.

Furthermore, it may be necessary to reduce the concentration of the insecticide in the product in order to preserve its stability at very low temperatures.

Water Content

In most circumstances the presence in an emulsifiable concentrate of a substantial quantity of water is undesirable. The water may be expected to accelerate the rusting of the iron container, iron compounds may be brought into solution, and these may react with the emulsifier, causing a gradual loss of emulsion characteristics. However, whilst there is good reason to specify that an emulsifiable concentrate shall not contain more than some minimum quantity of water, it must also be recognised that the preparation of anhydrous products is not generally practicable. Most solvents contain a small proportion of water and the bulk storage of solvents under anhydrous conditions is not possible.

Flash Point

Emulsifiable concentrates are generally prepared using one or more organic solvents, such as aromatic petroleum fractions, which are inflammable, and in some circumstances it may be important to ensure that the flash point is above some specified minimum temperature. The flash point affects the freight rate laid down by the transport authorites. Products with low flash points must be used with caution and in some circumstances their use may be forbidden. It is for the purchaser to decide the importance which he attaches to the flash point of the product, and the extent to which he is prepared to pay more money for a product which meets his requirements.

Properties to be Excluded

In contrast to the comments made above, it does not seem reasonable to set limits for the wetting properties of an emulsifiable concentrate, its surface tension, its adhesive properties or its long-term storage stability. While these properties are of importance, they cannot be measured on any absolute basis. Some indication of storage stability can, nevertheless, be obtained by means of an accelerated storage test similar to that mentioned above.

The specific gravity of an emulsifiable concentrate may be taken as an example of a property which can be measured accurately although its inclusion in a specification is not likely to be justified. Any limitation of the specific gravity would, for example, also limit the formulator in his choice of solvent, and this might prevent him from using an alternative solvent which would be cheaper or which would have other advantages.

WETTABLE POWDERS

A conventional wettable powder usually consists of finely ground particles of the biocide and of one or more mineral fillers, together with relatively small percentages of surface-active agents which impart to the powder wetting and suspending (or anti-flocculating) properties. Although the term 'wettable powder' is widely used, the type of product in question is perhaps more correctly described as a 'water-dispersible powder', because its most important property is not merely that it can be wetted with water but that it can be converted into a suspension which has a certain degree of stability. In other words, the particles will remain in suspension for an appreciable time after the powder has been thoroughly mixed with water, although they will inevitably settle out eventually.

What to Specify

The characteristics of a wettable powder which could be used in a specification include the percentage of biocide present, its suspension characteristics, its wetting properties, its ability to withstand storage, its acidity or alkalinity, and the distribution of particles of various sizes ; but it is not necessarily desirable that the specification should include clauses governing all these properties or others.

It is obviously important to specify that the wettable powder shall contain some minimum percentage by weight of the biocide and to ensure that reference is made in the specification to a suitable method (or methods) of analysis. One should also consider whether the amount of biocide in the wettable powder is likely to decrease during storage. It is known, for instance, that the fillers which may be used to prepare wettable powders can bring about the catalytic decomposition of many insecticides. This type of decomposition can usually be overcome and the competent formulator will always ensure that this is done. Nevertheless, it may be desirable in the specification to include a test whereby the percentage of the biocide is measured after the powder has been stored in the laboratory under conditions which simulate the effect of many months of storage in practice.

Suspension Characteristics

The most important physical property of the wettable powder is undoubtedly its suspension characteristics, because these determine the extent to which the product will be suitable for the purposes for which it is recommended. Powders possessing widely different suspension characteristics may be suitable for different purposes, but their suspensibility will, in all cases, be dependent on a variety of factors, including the hardness and the temperature of the water used to prepare the suspension, the concentration of the wettable powder in the suspension, and the conditions of storage to which the powder is subjected before use. It is clearly essential, therefore, that the specification should include a clause governing the suspension properties of the wettable powder, and that this should take into account the degree of suspensibility which will be necessary in practice, and the type of water likely to be used to prepare the suspension. It may well be desirable that the specification should also stipulate that the suspensibility shall not fall below some minimum value after the powder has been subjected to an accelerated storage test simulating storage in tropical countries.

'Wettability'

Although relatively simple tests have been devised for the measurement of 'wettability', it is difficult to standardise

the conditions of such tests so that repeatable results are always obtained, and it is also difficult to relate the results of such tests to the ultimate behaviour of the product under field conditions. It may be considered, therefore, that although tests which have been designed to give a measurement of the wetting characteristics of powders provide a useful means of *comparing* the wetting properties of different products, it can be unwise to make use of these tests in a specification relating to one particular product. As an alternative to a test for wettability it is possible, for example, to specify the procedure used in the suspensibility test in a way which ensures that a product with inadequate wetting properties will, in any case, be rejected.

Storage Properties

Specifications which require that a wettable powder 'shall have good storage properties', without defining in what way this property is to be measured, are obviously unrealistic. The extent to which the various properties of a particular formulation will be affected by storage, over a prolonged period of time and under varying conditions, is not something which can be measured quantitatively by any laboratory procedure. One could, however, obtain a reasonable indication of storage stability by means of 'indirect storage tests' (such as those mentioned above) which involve the redetermination of the percentage of active ingredients, or of the suspension characteristics after an accelerated storage test.

Free Acid and Alkali

There may be circumstances which make it important to know that a wettable powder contains no more than some given quantity of free acid or alkali. If this is so, a clause in the specification governing acidity or alkalinity would be acceptable. For example, the biocide in the wettable powder may undergo certain chemical reactions, in the presence of free acid or alkali, when the product is mixed with water. In other circumstances, such a clause could be undesirable. The formulator may, for example, use one or more alkaline components to improve his product in some way, e.g., by preventing or minimising loss of suspension properties during storage or by preventing the catalytic decomposition of the biocide.

Particle Size Distribution

Attempts have been made to specify the particle size distribution of wettable powders by means of a variety of methods involving sedimentation of the particles in suspension or the passage of air through the compressed powder. Such methods are often time consuming, they may involve the use of expensive apparatus and, in most cases, it is difficult to accept that the data obtained in this way have a direct bearing on the ultimate performance of the product. Certainly a wettable powder composed of coarse particles will not be of much use, but the presence in the specification of the test for suspensibility will ensure that no such product is accepted. Similarly, a product shown to consist substantially of very fine particles will not necessarily be a 'good wettable powder'. To ensure this, one must use an effective suspending agent and the test for suspensibility will show whether this has been done.

Agglomeration

As the particles of a wettable powder sometimes tend to agglomerate during storage, it is useful to include in the specification a test in which the extent of this agglomeration is measured, e.g., in terms of the percentage of the product which cannot be washed through a fine sieve under standardised conditions.

If specifications are drawn up on the lines which have been suggested above, the purchaser will have the guarantee of quality which he requires. At the same time, the formulator will be free to make the fullest use of the information gained from his research into formulation problems and manufacturing techniques, and he will be able to select the ingredients which, when blended together in the correct proportions, will provide 'balanced' formulations which will bring him most credit and his customers the most satisfaction.

INCREASING FAR EAST FOOD PRODUCTION

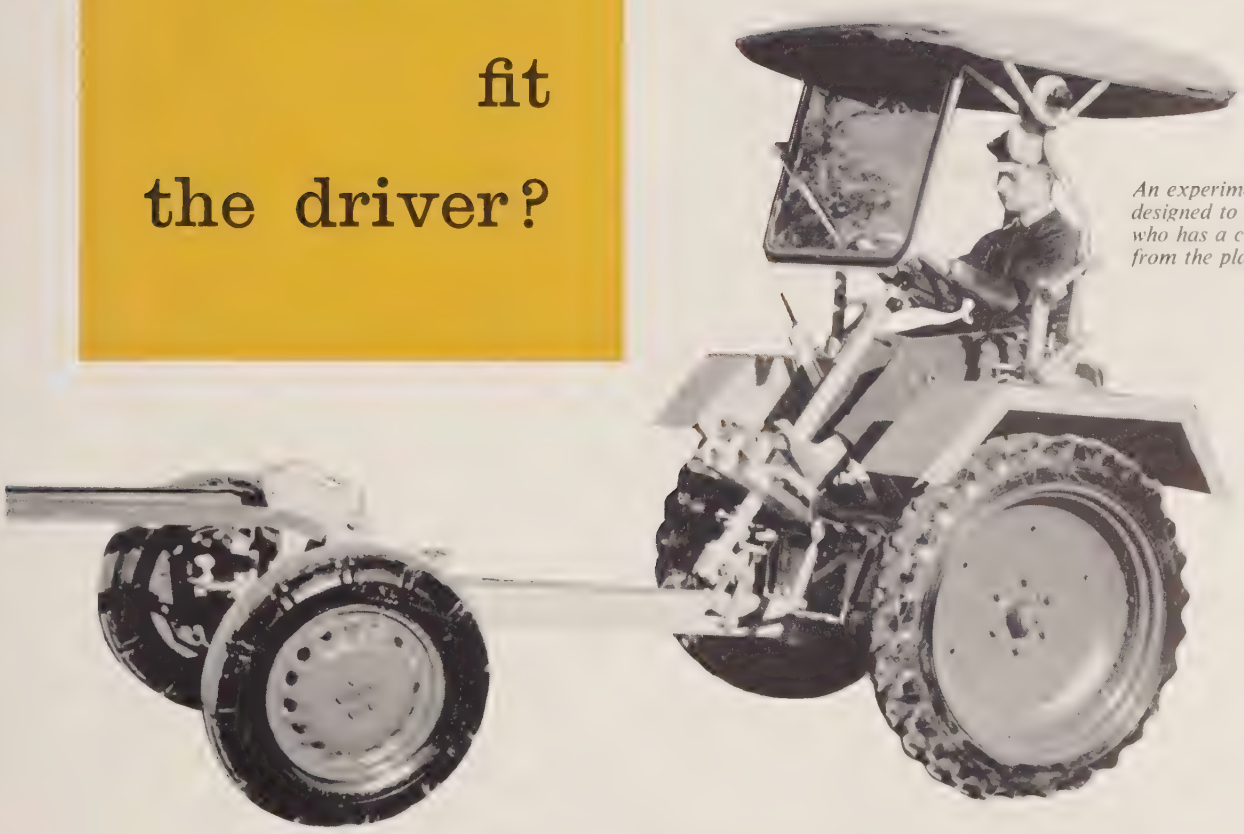
That the need to increase agricultural production was now being given such an important place in the development programmes of many Asian countries was what particularly impressed him after a visit to the Far East, Mr. A. C. Lowe, of Shell International Chemical Company, said in a recent broadcast on the BBC Far Eastern/African Service. This was in marked contrast to the situation 10 years ago, when industrial expansion was all-important.

There were two reasons for this emphasis on agricultural production in such countries as Pakistan, India, Thailand and Japan. First, that the earlier emphasis on industrialisation had placed severe strains on their economic resources; and secondly, that the increase in population in South-east Asia made it imperative to produce more food from a fixed land area.

The problem of increasing food production in Asia was being tackled in many ways, such as by education in better cultural techniques, by irrigation schemes, and by the use of better varieties of seed. But education took time and irrigation involved vast sums of capital. That was where the use of agricultural chemicals came in: in the same season in which they were applied they could give an increase in yield which repayed the cost of application many times over.

In West Pakistan last year 84,000 acres of sugar cane had been sprayed with endrin to control Pyrilla. The cost of the treatment was less than £1 per acre. The increase in value of sugar resulting from the treatment was about £35 per acre. As a result, Pakistan was self-sufficient in sugar in 1959 and did not have to expend valuable foreign currency on importing the short-fall in their requirements.

Can a tractor fit the driver?



An experimental tractor designed to suit the driver who has a clear view from the platform.

by **Dr. H. Dupuis,** *Max-Planck Institute of Agricultural Work Science and Engineering, Bad Kreuznach, West Germany.*

In recent years a new science known as ergonomics has come into being: it may be described as 'human engineering', or the study of man in relation to his work environment. It involves the application of anatomy, physiology and psychology to problems associated with, for example, the improvement of machinery design and other factors affecting the ease and efficiency with which a man can do his work.

So far, ergonomic studies have not been widely applied in agriculture, but, as the author of this article shows, experiments carried out in West Germany demonstrate that it is sometimes possible to reduce the energy expended by a tractor driver by as much as 45 per cent. simply by providing him with a well-designed seat and locating the controls in the most suitable positions.

In many parts of the world the tractor has become the major source of draft power on the farm. Since a tractor may be driven for as many as 2,000 hours a year by one man, it is natural that the conditions obtaining while it is being driven are likely to affect both the physiological stress on the tractor driver and his health. Several occupational hazards, including damaged intervertebral discs, displacement of the stomach, and bladder trouble, can be attributed to poor ride characteristics of farm tractors. In addition, the energy expenditure for driving a poorly designed tractor may exceed the recommended maximum rate.

In 1953 a cooperative research programme was started on this subject in Germany by the Max-Planck Institute

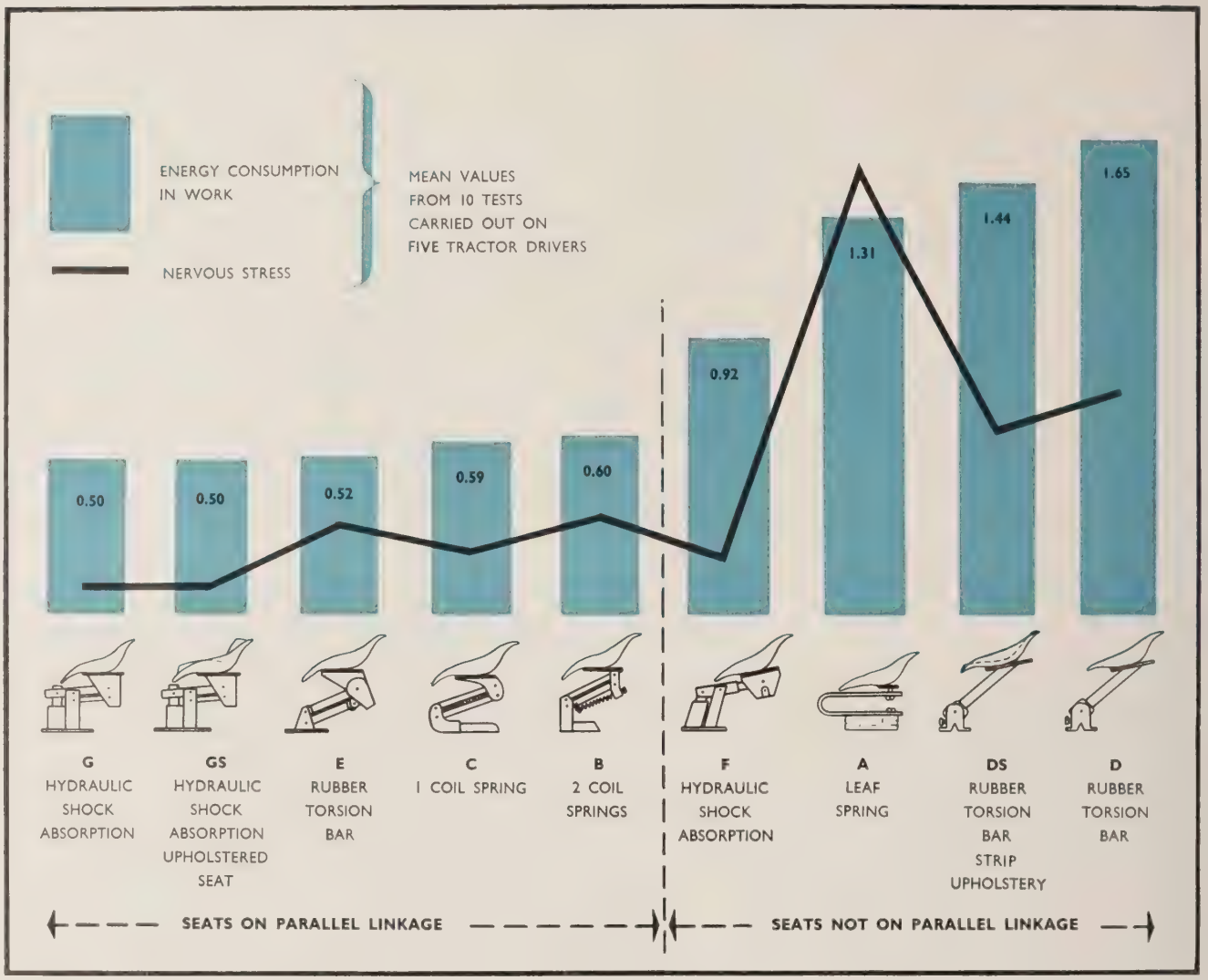


FIG. 1.
Physiological evaluation of tractor seats. The columns show the rate of energy expenditure; the line shows the level of nervous stress.

of Agricultural Work Science and Engineering and the Max-Planck Institute of Work Physiology. Since 1955 the work has been carried on at the former Institute. The results of these studies have been accepted in both Europe and the USA as providing the basic data for the design of a tractor which will fit the human frame. Some of the most important results are presented here.

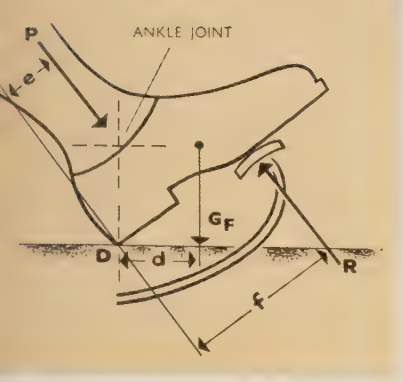
The physiological stress on the tractor driver can conveniently be divided into two components: sitting, and the operation of controls. Energy expenditure tests show that on average maintaining the sitting posture accounts for 40 per cent. of the energy expended, and that 60 per cent. is accounted for by operation of the controls.

Seating

The level of physiological stress is in part determined by the posture which the driver has to maintain in order to be able to operate the machine. A standing position normally results in greater stress than a sitting position, but even in a sitting position the stress may have a detrimental effect on health if severe vibrations from the machine are not damped. Moreover, the physiological strain depends to a great extent on how often the individual control levers have to be operated and the resultant strain on the arms and legs.

What are the essential factors to be taken into consideration when designing the best seat possible for tractors and agricultural machinery? It is generally assumed that the sitting position on a tractor is comfortable for the operator, but this is by no means always the case. Owing to vibration, which is particularly severe on rough farm tracks (because the tractor axles are not sprung) it may be no pleasure to sit on a tractor and drive it. It is a well-known fact that tractor drivers suffer from spinal, gastric and other occupational diseases, and the health of women who have to drive tractors may be affected to an even greater extent.

One method of reducing the strain on the tractor driver is so to design the seat that it minimises the vibration of



. 3 *The forces acting on the driver's foot; these are used for calculating the minimum return forces for the accelerator pedal (see text).*

A parallel linkage-mounted tractor seat in use in West Germany. It can be adjusted to the driver's weight and has a hydraulic shock absorber.

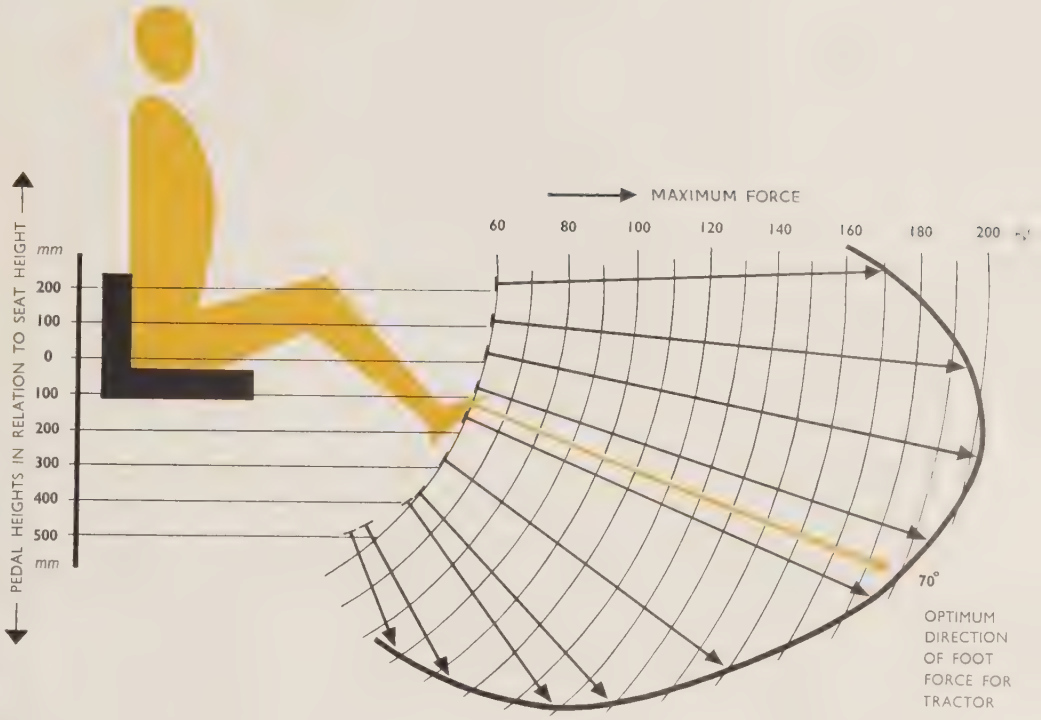


FIG. 2. *The relationship between the maximum thrust on a pedal and the height of the driver's seat above the pedal.*

the tractor and the physiological strain on the driver. The latter would be fully justified in insisting that he should be able to sit comfortably on the tractor which he has to drive all day.

The Ideal Seat

What is the ideal tractor seat? To settle this question, a group of tractor drivers was subjected to an ergonomic investigation. The drivers were exposed experimentally to vibrations of the different frequencies and amplitudes normally produced by a farm tractor, and different seats were used. As the drivers were being shaken up and down, they had to use their muscles in order to keep their posture. Physiological stress was measured in terms of energy expenditure.

From these experiments it became clear that the stress exerted on the driver varies greatly according to the type of seat (*see* Figure 1). Referring to this diagram, the energy consumption is considerably higher when using the seats to the right of the broken line (i.e., those not mounted on a parallel linkage) than when using those illustrated on the left (those mounted on a parallel linkage). For example, using seat D (rubber torsion bar; no parallel linkage) the driver's muscles have to work much harder, and the exertion is three times as great as that required with seat E (rubber torsion bar; parallel linkage). The reason for this may be that the seats to the left of the broken line can move only up and down, because their mounting has been arranged in the form of a parallelogram, whereas the radial movement produced with the other types of seat shakes the operator to a greater extent, causing a higher expenditure of muscular energy.

Nervous stress was also determined in the tests. This is particularly low for seats with hydraulic shock absorption, but it is very high when seats have poor suspension and shock absorption as, for example, seat A (Figure 1) which has only a simple leaf spring.

The position of the tractor seat should be adjustable to

suit the height of the driver, as with seats in motor cars. It should also be possible to adjust the hardness of the seat suspension to the weight of the driver.

The shape of the seat is also important; a moulded seat is most suitable, because it enables the driver to sit comparatively firmly and safely even when operating the tractor on hillsides. If there are many steep slopes in the area in which the tractor is being operated, it is worth considering using a moulded seat which can be adjusted horizontally; horizontal adjustment of the seat can considerably reduce human strain. The sides of the moulding should be high enough to prevent the driver from falling off the seat. At the sides and rear, the seat should be covered with foam rubber or plastic to protect the pelvis against shock.

The back of the moulded seat should be about 10in. (240mm.) high, measured from the top of the upholstered seat, to provide support for the driver's back when he is operating the foot pedals. Higher back rests than this are not to be recommended; first, because movement of the upper part of the body would be severely restricted when rear hand levers are being operated; and secondly, because the skin over the vertebral column is easily rubbed, particularly if the upholstery is inadequate.

The ideal tractor seat should therefore have the following characteristics:

1. Mounted on parallel linkage to ensure vertical motion;
2. Good suspension and shock absorption;
3. Suspension adjustable to the weight of the driver;
4. Seat position adjustable to the height of the driver;
5. Sides and back of the seat of correct height;
6. Resilient and durable upholstery;
7. Durable water-proof seat cover.

Hand Controls

Not only is a tractor equipped with more controls than a motor car or lorry, but they have to be used more frequently and require greater effort in their operation. Moreover, the tractor driver often has to do a considerable amount of manoeuvring work, and also has to control from the tractor seat mounted or drawn machinery.

The controls which are used often should be placed so that they can be reached quickly and operated easily. The steering wheel is operated continuously, and the driver also has to use the gear lever and the control for the power lift frequently. Both controls should therefore be near the steering wheel so that they can be reached easily, but they should not be so close to the steering wheel or the body of the driver that they could be operated unintentionally. The gear lever should not be below the steering wheel (i.e., between the driver's legs) but to its right or left, as in a motor car. The power lift control should be arranged in a similar way.

The controls that are not used so frequently but which require a greater force for operation should be arranged in such a way that the stress on the driver is kept as low as possible. In the same way as the height from which a man lifts a sack affects the ease with which he can do it, the force necessary to apply a hand brake or to disengage a mowing machine also depends on the location of the controls. Since the maximum force is exerted when the arm is almost fully extended, hand levers, which require a considerable force for operation, should not be located too close to the driver's body.

Pedals

As with hand levers, so with pedals: the thrust which the driver can exert on the pedal depends on its location. In particular, if the pedal is too far from the mid-line of the body, the force which the driver can exert is reduced. The brake pedal and the clutch pedal should therefore be located directly in front of the driver's feet.

The location of some tractor pedals is very low in relation to the height of the seat; this is a disadvantage to the driver because he cannot press against the back of the seat when operating the pedals. The difference in height between the brake and clutch pedals and the seat (Figure 2) should not exceed 5in. (130mm.), which means that for a driver 5ft. 8in. (1.7m.) tall the distance between pedal and back of the seat would be approximately 37in. (935mm.) when his legs are slightly bent.

The pedals which are less frequently used (i.e., the power take-off shaft control, when this is not hand-operated, and the lever for the differential lock) can be placed closer to the seat; this makes it easier to avoid unintentional operation of these controls.

The speed of the engine (and thus of the tractor) can be controlled in the field by using an adjustable hand lever; but when the tractor is driven on the road changes in speed should, as with motor cars, be effected with a foot pedal, which provides more precise control. The energy required for operating the pedal must not be too great or the driver will become fatigued; on the other hand, if the driver has to keep his foot only lightly on the pedal, the strain on the muscles will be considerable and will also result in fatigue. The minimum force required for operating the accelerator pedal may be calculated as follows (*see* Figure 3):

$$R = \frac{(G_F \cdot d) + (P \cdot e)}{f}$$

$$R = \frac{(1.46\text{kg} \cdot 92\text{mm.}) + (7.8\text{kg} \cdot 64\text{mm.})}{200\text{mm.}} = 3.17\text{kg or } 7.05\text{lb.}$$

R = Resistance = 3.17kg.
G_F = Weight of foot in kg.
P = Weight of leg in kg.
d and e are distances in mm.

To avoid undue eye strain and consequent nervous stress on the driver, the tractor should provide as clear a view as possible of the equipment to be operated. By incorporating these points in the design of a tractor, as has been done in the experimental tractor illustrated, the strain on the driver will be reduced considerably.

Agriculture and Ecology in Africa. JOHN PHILLIPS. Faber & Faber, London. 63s.

The flow of books on tropical agriculture is developing into a steady, and welcome, stream. But this latest addition is an unusual one. Professor Phillips was born in South Africa and has been in turn a forester in the Knysna, an ecologist with Tsetse Research in Tanganyika, Professor of Botany at Witwatersrand, and a senior officer in the East African Groundnut Scheme. He has undertaken several missions as consultant to the World Bank and is now Professor of Agriculture at the University College of Ghana. From this experience he writes with authority, unfettered by any metropolitan interest.

The sub-title of the book is *A Study of Actual and Potential Development South of the Sahara*. It is too realistic to be orthodox and some of the views expressed are not calculated to please the pundits. The book is clearly meant to be of service to representative governments, present and future, and there is no doubt about the sincerity of Dr. Nkrumah's foreword.

Unfortunately for metropolitan readers the author's florid style in discussion makes very difficult reading. The purely descriptive material is a little easier. But those who like subject, verb and object in this order will not get far with this book. This is a pity, because the 366 pages of text, supported by some 750 references to literature, bring together a great wealth of information and many of the ideas expressed deserve attention.

Book One starts with six reasons which prompted the author to write the book. No right-minded person will quarrel with the first of these, which, stated briefly, is a desire to substitute realism for wishful thinking. His other reasons are concerned with the adjustment and adaptation which agriculture must undergo to keep pace with social, economic and environmental changes, and with the need to study ecology when planning. Then follows an elaborate codification of the bioclimatic regions of Africa south of the Sahara, supported (between bibliography and index) by a coloured map compiled from 'literature and observation'. There is still plenty of room for maps of this kind, setting out the ideas of people who really know Africa, especially when they are modestly offered as an 'Aunt Sally'. Further discussion of the environment and problems presented by vegetation, soils and animals completes Book One.

The next two books, each of nearly 100 pages, describe the forest and wooded savanna regions. The characteristics of each sub-region are described and tabulated in detail in the code devised for the purpose, and each book concludes with a valuable chapter on land use. But, alas, there is not one single photograph to illustrate what is described!

Book Four deals with all the difficulties—health (man and beast), water, communications, famine and poverty. This is good realistic stuff, written by someone who knows and understands the continent he is describing. He also writes from first-hand experience when he mentions the folly of rushing 'development schemes' in the teeth of difficulties that have not

been squarely faced. Perhaps it is easy to be wise after the event, but the comparative study of the Sudan Gezira Scheme (successful), the East African Groundnuts Scheme (failed), and the Volta River Project in Ghana (still planning) is an example of the kind of study that should command attention.

Book Five summarises conclusions and rounds off the philosophy. It is a mixed bag with some good features. I like the author's straightforward acceptance of shifting cultivation (p.372) and his statement that the traditional system ought to be better understood. He hits another nail on the head by saying (p.384) that the ecology of crops has not been sufficiently studied in Africa.

Apart from 'A-balance' for 'imbalance' on p.360 there are not many glaring errors. *Pseudococcus* spp. (p.63) are mealybugs and not aphids, and a reference to the work of Storey and Leach on tea 'yellows' (p.158) would be appropriate. But the real trouble with this book is that hardly anyone in the 'over-developed' countries will have the time and patience to read it all. Which is a pity. What is wanted here is a well illustrated book of half this length and half its price. J. D. JAMESON.

Soil Conservation. HELMUT KOHNKE and ANSON R. BERTRAND. McGraw-Hill, New York, Toronto and London. 52s. 6d.

One has come to expect factual straightforward treatment of technical subjects in the McGraw-Hill series on agricultural sciences, and in *Soil Conservation* we are not disappointed. This is not to say that the subject is handled cookery-book fashion—far from it. Dealing in principles and fundamentals, well illustrated by reference to agricultural practice, the authors have drawn widely on authoritative and practical sources. A fairly comprehensive bibliography is given.

Running to 289 pages this is by no means a Bennett (oddly enough neither Bennett nor Gustafson seem to be mentioned in the bibliography) but it is an excellent text for students and others wishing to get a general idea of what soil conservation is all about. The background is to be found here against which the significance of conservation programmes and the problems of conservation farming can be thrown into relief. The style may become a little irksome to those of us who left college longer ago than we would care to admit; but for examiners and examinees it will have a familiar and comforting ring. I would not recommend this book to an inexperienced farmer friend seeking advice on how to conserve his farm unless I was sure he was also in touch with a knowledgeable conservationist capable of providing the practical guidance which is so essential to planning and executing a conservation programme.

The authors do not overlook the philosophy of conservation; and the importance of 'right thinking' about the soil is emphasised from the outset. Happily, the book is quite free from the etherial thinking of the 'compost-and-mystery' school —the work is much more constructive than that.

The first part of the book deals with erosion and its causes. After 142 pages we get to the conservation aspect; and hereabouts the authors show how the 'limits of permissible erosion' can be calculated. Such formulae have a fascinating appeal but it will be many a year before most of the world's agriculturalists are in a position to take this chapter at its face value; yet even here useful principles are expounded.

Methods of conservation are clearly described with the help of good photographs, diagrams and tables, but with a minimum of practical data for the farmer. It is good to see a chapter on problems of economies and the cost of conservation farming, an aspect that is often overlooked in agricultural textbooks; and it is interesting to note in passing that the time required by a Mid-west farmer to change over from ordinary to conservation farming is usually from one to six years according to the economic status of the farmer. Sections dealing with farm planning and land use classification make particularly interesting reading. J. E. MAYNE.

Fertilisers and Profitable Farming. G. W. COOKE. Crosby Lockwood, London. 15s.

Efficient Use of Fertilisers (revised and enlarged edition). Editors, VLADIMIR IGNATIEFF and HAROLD J. PAGE. FAO, Rome. $4.50 or 22s. 6d.

Fertilisers and Profitable Farming

For some time a concise book on modern and economic fertiliser use has been needed. Dr. G. W. Cooke, Head of the Chemistry Department at Rothamsted, has filled this gap. It is not a belated contribution; only a few years ago a book of this kind would have been premature despite the need for it. The 1940s and the 1950s have been two decades of vigorous expansion in British fertiliser use—first, to produce more food from neglected pre-war soils; later, to achieve higher yields per acre in order to reduce costs of production. Throughout this period there have been other major changes, all affecting in one way or another practical recommendations for fertilisers: the ever-increasing use of combine drills and consequent placement of dressings, the introduction of new cereal varieties resistant to lodging and much more responsive to nitrogen, new policies of crop rotation and to some extent (though not yet nearly enough) new farming attitudes towards grassland and its utilisation. These have been 20 years of fertiliser revolution, and it has taken time for firm recommendations about fertilisers to emerge from its very mixed melting-pot.

The end of the 1950s is probably the best time to attempt a summing-up. On much of the best-farmed arable land optimum fertiliser rates are already established. Further expansion in UK fertiliser use, though it should be substantial, mainly depends upon developing more generally this optimum standard. Dr. Cooke's book is a blue print that should cover the 1960s. No-one in the country could have been better fitted by experience to write it than the successor to the late Dr. E. M. Crowther, whose earlier work so powerfully influenced the 1940s.

As a scientist associated with some of the most important post-war plot and field research work on fertilisers (optimum rates for crops, methods of placement, etc.), Dr. Cooke might have written a book more suitable for other scientists than for farmers. He has resisted this easy temptation. The whole of his text should be comfortably understandable to the reasonably intelligent farmer. It is important to stress that this is a book *for farmers*.

One of the basic difficulties in stating fertiliser recommendations is to decide upon the 'yardstick'. To state them in hundredweights per acre of the various kinds of fertilisers is cumbersome and becomes confusing. To rely upon pounds of N, P_2O_5 and K_2O per acre, though logical and effective in scientific literature, involves small numbers and decimal points, the kind of arithmetic that irritates the British and non-metric section of Europe. The N—P_2O_5—K_2O ratio system has always brought more complication than clarity. Dr. Cooke has plumped for the unit system: for example, 1cwt. sulphate of ammonia, with its 21 per cent nitrogen, is 21 units of nitrogen. It will be a valuable by-product of the book if as a result this system is more widely used.

Much field trial evidence is cited to show the general reliability of modern recommendations for most profitable rates of use, most effective placement methods and suitable times for

dressings. The fertiliser needs of arable crops are thoroughly stated and with adjustments required for types of soil and climatic variations. Fertiliser recommendations for grassland are not as definite, both because this field of use still requires much more investigation and because there are so many variations in grassland soil statis, in sward composition and in the utilisation of grass when grown. Rightly, Dr. Cooke's grassland recommendations are presented more as suggestions than prescriptions. His tabulated summary of these suggestions —for common types of grassland and its management—should prove a valuable advisory contribution, and a sound basis for the much needed forward stride in UK grassland farming.

This is a most notable book. Its readability has not been achieved by misleading over-simplification, and its 120 or so pages of text are a triumph of straightforward, non-digressive writing. Too much agricultural literature has become repellently formidable. Will enough farmers read a book that has been so deliberately and effectively written for them?

* * *

Efficient Use of Fertilisers

A new and almost entirely rewritten edition of FAO's *Efficient Use of Fertilisers* could hardly be in sharper contrast. The subject is the same, but where Dr. Cooke has been concerned only with British conditions the FAO book covers world conditions; whilst Dr. Cooke has aimed at farmer-readers, the FAO book is aimed at advisers, teachers, etc. Two editors and 96 expert contributors have created this new edition, now more than twice the size of the original 1949 edition. As a reference book, it is superb—and at its price superb value too. Whether such a book covering, as it must, widely differing soil, climatic, cropping and national economic conditions, can in fact foster greater fertiliser use is a realistic query. Is it useful to accumulate so much in one book? Is it practical in a chapter called 'Cropping Systems and Fertilisers' to deal with Britain, France, Norway, the USA, Egypt, South Africa, India, the Belgian Congo, Java, and other countries? To raise these questions is not to criticise the text or selection of material—the style and clarity of presentation is in fact remarkably even, to the credit of the two editors. If a well-documented study of world fertiliser use, actual and potential, is required, it is doubtful if this book could be bettered, and probably it could have had no other origin. Its prestige value for the world-wide profession of advisers and for the world industry of fertiliser manufacturers must also be considered, However, more concise books such as Dr. Cooke's, aimed at local agricultural and economic conditions, seem much likelier to make a real impact upon fertiliser use.

A common feature of both books is worth mention. Each is franker about the limitations of soil analysis than most similar literature would have been 10 or more years ago. At one time total faith in this approach to fertiliser needs was all too optimistically promoted. D. P. Hopkins.

Bananas. N. W. Simmonds. Longmans, Green, London. 45s.

The banana may, as in Great Britain and many other industrialised countries, constitute no more than an adjunct to an already satisfactory diet, or it may represent the major source of dietary carbohydrate (and have many other minor uses), as in some tropical regions where consumption approaches 10lb. per person per day.

Whether as a direct source of food, or as a source of foreign exchange, the banana is the foundation of the economy of many tropical countries, and interest in this crop is therefore widespread. This book is a veritable mine of information about the banana and one which may be read with pleasure, and often with profit, by all who are interested in this plant.

The rather unequal treatment given to the different aspects of the subject arises from a deliberate policy on the part of the author. The botanist will appreciate the full treatment accorded to the botany of the banana and its cultivars, whilst those whose main interest is in banana cultivation may well profit from the descriptions of the cultural practices which obtain in countries with which they are unfamiliar. Specialists in plant pathology and insect biology may be disappointed to find that only the major pests and diseases of the crop and their control are described, but the student of tropical agriculture will feel grateful to the author for this selection. Concise accounts of cultural methods, of transport problems, of composition and utilisation, and of the economics and history of the banana industry serve to round off a very complete treatment of the subject.

Of particular value is the author's analysis of the causes of seedlessness and of the problems that this and polyploidy introduce into a breeding programme. A most ingenious analysis of the climatic data of the main banana growing areas results in tentative conclusions about the rainfall and temperature requirements of the crop, although perhaps only a phytotron can provide a complete picture of the environmental requirements of this plant. But an application of Penman's work on potential transpiration might have yielded more precise information about the water requirements of the banana plant. Conclusions about manurial requirements, desirable spacings, propagation, and suitable conditions of transport and storage rest on a more secure foundation, based as they are on experimental data.

The sections of the book which deal with the economic aspects of the industry raise at once the question of the future of banana growing, and this is something which even a prophet might hesitate to forecast. With a yield of five tons an acre considered as good, the survival of the banana as a major food crop, if and when rising standards are enjoyed by its cultivators, is questionable; for despite the advantage of uniformly favourable temperatures and an abundant water supply, yields compare unfavourably with those of potatoes (a food crop) and apples (a fruit crop) in the United Kingdom. Possibly a fuller utilisation of the plant, as already practised by some 'primitive' people, as for instance the Chagga tribe of Kilimanjaro, will provide the answer to this problem.

Throughout the book sources of information are given, so that the reader, in addition to the text, is provided with a bibliography of the most important banana literature, whilst the five indices (general, personal names, place names, clone names and scientific names) allow easy reference to any topic and the numerous carefully chosen plates serve to illustrate the already clear cut text.

Without doubt this is the most up to date and clear account of the many aspects of the banana plant and of the banana industry, and one for which a wide range of persons—botanists, tropical agriculturalists, industrialists and many others—will be grateful. L. G. G. Warne.

Soil, Grass and Cancer. Andre Voisin. Crosby Lockwood, London. 30s.

> With me along the strip of herbage strown
> That just divides the desert from the sown.

That is where the author would lead us, and lead us very skilfully, and lose us. On the one hand are the hard, and in some ways uninviting fields of science. What grows there has been described and labelled, and makes no appeal to the imagination.

On the other hand is the enticing wilderness, with patches of bright flowers, and flashing butterflies that, with each attempted capture entice those with a bent for exploration still further towards the blue mountains in the distance.

The theme is an ecological one, of animals having evolved along with plants that use the substances naturally occurring in the soil for the synthesis of their organic constituents. Through the intermediary of vegetation the author sees the normal functioning of the animal body to be linked with the constituents of the soil in the balanced inter-relationship in which they occur there; and he sees alterations in the natural soil (through the workings of modern agriculture) as responsible for cancer and for many other ills of animals and of man. It is only in the presence of this normal balance that the plant is able to build up those very particular organic complexes that fit the requirements of the animal body.

This theory is developed in an intriguing way that impels the reader to go on eagerly from one chapter to the next. 'Milk which Produces Idiots' is a chapter heading that urges one to find out why, and 'Agronomic Original Sin' another that leads one to read how malformed offspring may be traced to deficiencies in maternal diet. These are characteristic of the originality of the author's approach. He seems, however, to be less familiar with the biological than the chemical aspect of his subject; enhanced susceptibility of fowls to 'typhus' is traced to dietary deficiencies and many poultry 'infections' are said to be 'caused by worms such as the Ascaridae'.

The scientific scepticism that is such a valued part of research equipment is, however, lacking; there is not nearly enough doubt in the book. The author shows too ready an acceptance, and even the selection of wished-for evidence. But, after all, is it not from the uncharted wilderness that new ideas come? It is the explorers who bring in what is new for the gardeners to tend, and what was a wild seed of imagination yesterday becomes the cultivated plant of tomorrow. Even if M. Voisin is not able to convince the scientists that he has something for which they have been seeking, he has given them ideas to think about and presented these in a book that is a pleasure to read and a model of concise writing. E. L. TAYLOR.

A History of British Livestock Husbandry. Vol. II, 1700-1900. R. TROW-SMITH. Routledge & Kegan Paul, London. 40s.

Mr. Trow-Smith has the gift of writing history that is both erudite and readable. Moreover he deals with a subject too long neglected in print and, for that reason, his book is doubly welcome. The student of Britain's livestock heritage has been to date condemned to specialised breed histories, doubtful propaganda by breed societies or difficult research into bygone books and articles. I know of no modern farming book which even begins to compete with Mr. Trow-Smith's in this field.

It starts in the eighteenth century when Britain was a large country in the sense that life was parochial, communication was difficult, and men from the south-west felt probably as remote from their fellows in the north of Scotland as we do today from Siberia. The farm livestock was a hotch-potch of local types of unknown origin, each merging imperceptibly into the next, indifferently managed and haphazardly bred. The book covers the great surge of improvement that then took place, and takes us to the edge of the modern age—one of defined and specialised breeds, of Breed Societies and pedigree registration, marketing boards, production recording and scientific feeding. It is, perhaps, a pity that the history does not carry through until the start of the Second World War. The author may be right that 'when men's memories arise it is time for history to go to bed', but I believe that history will finally decide that an era of livestock husbandry ended and another began when artificial insemination became commercially possible during the early 1940s.

On the eighteenth century this book is superb—a vivid picture of men and methods of that age. The emphasis and balance may have shifted—beef to milk, wool to mutton—but much of the background remains curiously the same today. And some startling figures are revealed: a Longhorn herd averaging 600 gallons a year; Shorthorn yields quite commonly recorded in the 5-10 gallon range; Bakewell receiving up to 400 guineas for a season's letting of one ram; a pen of five New Leicester ewes selling at 310 guineas. How much would that represent today?

By contrast the author is less happy in the nineteenth century —'a period of consolidation rather than of progress'. This is, perhaps, too sweeping. The great breeders of the nineteenth century were certainly as progressive as their forebears and deserve closer study. Moreover, I was surprised to find scant mention of the growth of agricultural shows which, for all their critics, have made a vast contribution to the improvement of animal husbandry; and no mention at all of the growth of breed societies and pedigree registration, which are now the cornerstone of our modern breeds.

The old imponderables remain. Is breeding an art or a science? How much of the pedigree goes in at the mouth? Rightly calling it a 'scientific art', the author treads a careful path between the altar of the mystic eye and the graven image of the Boutflour School. It is good, however, to find a modern writer who does not subscribe to the fashionable debunking of the master breeders.

Whatever mistakes they made (and their descendants still do) these men evolved defined and specialised breeds from chaos, and, moreover, sent them all over the world so that today there is no continent and few countries in which they cannot be found in some shape or form. As we plunge further into the scientific age—mass AI, deep freeze, progeny testing and statistics by the ton—it is well that such books as these should record their achievements. We may have need of their like again. C. J. N. STANFORD.

Beef Cattle Husbandry (second edition). ALLAN FRASER. Crosby Lockwood, London. 21s.

Dr. Fraser's book needs no introduction. Since publication in 1953 it has been widely recognised as one of the best modern books on this subject. The second edition has been refreshed by three new chapters to bring the book up to date.

The first explains the British beef grading and subsidy system in a way which only a writer of Dr. Fraser's clarity can do, but his clarity only emphasises the absurdities which exist. The problems which bedevil the pig industry in Britain at present could easily be reflected before long in her beef industry. How can any breeder set about producing the economically ideal beef or pig carcass when nobody is agreed what such a carcass is, and when, in any case, public taste has already altered once in our lifetime and may well do so again?

Perhaps the chapter on foreign breeds has been introduced primarily because of the present desire to import the Charollais breed for crossing purposes into the UK from France. Despite the many merits of these cattle, one cannot help wondering whether Britain has not already a sufficient number of breeds.

The chapter on recent scientific developments is of interest for the future. Undoubtedly scientists can do much to improve beef production and quality, but one hopes that both scientist and breeder will remember that each has much to offer the other. C. J. N. STANFORD.

Potatoes à la Portugaise

Across the Tagus, not far from Lisbon, in the southernmost section of Estremadura, lies a rich agricultural area enjoying one of the finest climates in Europe. It is here, around the pretty white villages, that early potatoes are grown for the nearby Lisbon market. There was great concern when, mysteriously, the crop began to decline. Each year, in spite of intensive husbandry, the soil yielded less. The authorities were called in and, in a survey discovered that the losses were due to the fact that nearly a third of the area was under attack by the potato root nematode (*Heterodera rostochiensis*).

Immediately, trials were undertaken with the highly effective Shell soil fumigant, D-D, which was injected into the soil four weeks before planting. A wise move indeed for, on lifting the potatoes in the following summer, it was found that the yield had increased from an original 6,000 kgs. to 22,000 kgs. per hectare—an increase of *over six tons per acre*!

Neighbouring farmers were so impressed by these trials, which had been carried out under official auspices, that they began to apply the D-D treatment of their own accord. Today, many of them regularly fumigate their land, before planting, with D-D, especially where potatoes are grown year after year in the same soil. With D-D, the farmers are getting 'second helpings' . . . of potatoes *à la portugaise*.

D-D

D-D is one of a series of Shell pesticides—aldrin, dieldrin, endrin, D-D, Nemagon and Phosdrin—that controls virtually every major world pest. If you have a pest problem, consult your Shell Company.

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